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## **The Global Airline Company: Agent of Market Power or Competition?**

**Paz Estrella TOLENTINO and Sabine REIM<sup>1</sup>**

### **INTRODUCTION**

The paper seeks to analyse the global airline company in the post-US deregulation era in the context of the two different views of the firm in economic theory. On the one hand, a firm can be regarded as an entity that takes decisions over prices and output and maximises profits from increasing its degree of market power. Alternatively, the firm can be seen as a device for innovation and knowledge creation and earns higher profits from creating 'new combinations' in production (Schumpeter 1911) or new areas of social or productive capability (Cantwell 2001). While the distinction between the pursuit of profits and profit maximisation may have little significance in a sufficiently stable and repetitive decision context, the significance of the distinction increases under conditions of substantial, non-repetitive change (Nelson and Winter 1982). The first view is associated with the neo-classical analysis of the firm, while the second view is linked with classical, Schumpeterian and evolutionary analyses of the firm.

The main argument of the paper embodying both theoretical and empirical elements is developed in several stages. The disparate perspectives in the theoretical economics of the firm are analysed in the subsequent section, followed by their application to the behaviour and competitive position of profitable firms in the global airline industry. The main findings of the study are contained in the concluding section.

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## THE THEORETICAL ECONOMICS OF THE FIRM

Penrose (1959) envisaged two different functions of the firm.<sup>2</sup> Within the standard neo-classical theory of price and production, a firm is an entity that takes decisions over prices and allocation of resources in order to maximise current profits, defined as the difference between the firm's revenues and costs. The firm is assumed to produce a single, perfectly divisible, standardised product for which the cost of production is known with certainty. The firm is also assumed to have certain knowledge of the volume of output that can be sold at each price. These 'demand conditions' depend on the behaviour of consumers, and the structure of the industry in which the firm operates (Davies 1992). Since there is no independent scope for managerial strategy, the firm is a "black box" responding uniformly to changes in demand conditions. Thus, for example, higher levels of industrial concentration provide firms in an industry a greater degree of market power, as reflected in higher profits.<sup>3</sup> Competition is defined in terms of market structure in steady-state equilibrium. The firm in the neo-classical economic model of the firm is thus a theoretical construct that results from the logic of optimal pricing and input combination.

Within the classical, Schumpeterian and evolutionary approaches, the firm is an active agent of innovation and knowledge creation that leads to "new combinations" in production (Schumpeter 1911) or new areas of social or productive capability (Cantwell 2001) in search of higher future profits through appropriate capital accumulation. This view of the firm accommodates the dynamic concepts of competition and entrepreneurship whose logical plausibility is enhanced by empirical relevance and

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<sup>2</sup> For further discussion of the two different functions of the firm, see Tolentino (2000, 2001a).

<sup>3</sup> This is a view associated with the structure-conduct-performance paradigm in conventional or neo-classical industrial organisation theory.

operational meaning in terms of contemporary business behaviour (Tolentino 2001b). Competition is defined in terms of the mobility of resources within and between firms, and the balance of forces between firms in an industry (Cantwell 1991). Rather than having an atomistic firm in the neo-classical mould, the alternative view of the firm is that of an institution with strategies and tactics, i.e. an active agent whose behaviour can cause changes in levels of industrial concentration. The advocates of this viewpoint have long challenged the 'market power' view of the firm that see the industrial concentration-profitability relationship as evidence of the ability of powerful firms in highly concentrated industries to acquire and use monopoly power. Those in the 'competitive' view advocate instead that industrial concentration may be the result of a desirable competitive process.

## **THE THEORETICAL ECONOMICS OF THE FIRM IN RELATION TO THE GLOBAL AIRLINE INDUSTRY**

To analyse the theoretical economics of the firm within the context of the global airline industry in the post-US deregulation era requires a short historical account of the evolution of regulation in the commercial air transport sector. This provides the necessary backdrop to the analysis of the impact of the regulatory changes associated with privatisation, competition and liberalisation/ deregulation throughout much of the world's airline industry in the past two decades on the behaviour and competitive position of profitable airline companies.

*The History of Regulation in the Commercial Air Transport Sector*

Following the Paris Agreement in 1919 that recognised the sovereignty of governments over the air space above their territories (Shaw 1990, Jönsson 1987), the political economy of the commercial air transport sector has developed within, and become inseparable from, national interests and political advantage from its earliest beginnings. The strategic role of commercial air transport in trade, mail services, foreign political linkages and domestic employment in the 1920s and 1930s helped to define the role of airlines as guardians of national interests and the embodiment of national identity. This factor in combination with the perceived adverse consequences of unregulated competition in the industry on the public interest (Richmond 1971) explain both the high degree of government protection in the industry, most prominently expressed in the form of strict regulation, and the conduct of the airline business without regard for economic implications or commercial significance (Graham 1995).<sup>4</sup>

As commercial air transport became an important means of mass travel in the 1960s rather than merely a strategic tool for the attainment of national goals, airlines assumed a more complex role apart from simply being guardians of national interests and the embodiment of national identity. As well-being of consumers also assumed importance in domestic and international air transport markets, the costs and benefits of rigid regulation were re-assessed, and led to an array of research on the advantages of freer competition in air transport (Straszheim 1969). In particular, the absence or limits to

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<sup>4</sup> The adverse impact of unregulated competition in the sector on the public interest was first evident in the United States where the initially unconstrained domestic market for aviation trade virtually collapsed following chaotic economic conditions, little security and low safety margins (Doganis 1991). This led to the introduction of strict regulatory controls of the domestic market in 1938.



freedom over prices, and the powerful market entry barriers prescribed by existing international regulations were regarded to have an adverse effect on consumer welfare.<sup>5</sup>

While the accumulating business misfortunes of international scheduled airlines in the early 1970s were addressed initially by increased government protection of home-based air carriers, a more widespread attitude in favour of more relaxed regulation was eventually reached, initiated in particular with the liberalisation of the domestic market of the United States with the US Airline Deregulation Act of 1978.<sup>6</sup> Indeed, the Act was a watershed in the regulatory frameworks of the international air services industry in support of free-market aviation economics associated with regulatory freedom and privatisation of firms and infrastructure (Graham 1995). The Act in combination with adverse business conditions in the industry set in motion the slow but decisive push towards greater liberalisation of international air services world-wide, as other countries increasingly moved away from their protectionist, bi-national stance and subscribed to greater liberalisation from around 1976.<sup>7</sup> This was first evident in attempts of government agencies to relax restrictions on fares and route authorities (Graham 1995), the virtual deregulation of freight charters in 1976 (Doganis 1991), and the European Commission draft proposal for a single and liberal European air transport market in 1975 (Lyle 1995).

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<sup>5</sup> The arguments in favour of deregulation and liberalisation in aviation were driven initially by concerns for consumer welfare rather than considerations of economic efficiency. The shift in favour of enhancing the economic efficiency of companies stemmed from the substantial business misfortunes brought about by the aviation crisis of the 1970s.

<sup>6</sup> In the late 1970s, the United States began to shift its aviation policy dramatically towards deregulation and minimisation of regulatory controls concerning trade in domestic and international air services. Such shift was precipitated not so much on account of the need to protect consumer interests as by the need to protect American air carriers in light of the rapid decline of their 'once-dominant' market share *vis-à-vis* foreign competitors. Consequently, the United States under the Carter Administration advocated a new policy of 'consumerism', greater competition, and the need to increase American airlines' share of international air transport. This led to the pronounced intention of other governments to assess the position of their own airlines (Doganis 1991).

<sup>7</sup> The trend towards liberalisation outside the United States was a long and drawn-out process from conception to implementation owing to continuing fears of American domination of the industry world-wide.

The International Air Transport Negotiations statement was issued in 1978, which was based commonly on the philosophy to protect consumer interests as a means to further national self-interests.<sup>8</sup> The statement represented the first step in the regulatory liberalisation of the industry at the world level, and defined a new global order for the airline industry (National Commission 1993).

An important development since was the wave of successful renegotiations of bilateral Air Services Agreements (ASAs) in favour of the United States. The strategy of American airlines to penetrate the North American and Pacific markets with 'beach-head' agreements served to force more recalcitrant governments into renegotiating their bilateral agreements with the United States (Graham 1995), particularly between 1978 and 1985 (Doganis 1991). The successful renegotiations of bilateral ASAs in favour of the United States and the strengthening position of American mega air carriers through increasing firm and network size — resulting from mergers and hubbing activity at the national level following US domestic deregulation — served to increase greatly the competitiveness of American air carriers relative to foreign air carriers that remained constrained by tight domestic and international regulation. The enhanced competitiveness of American air carriers in their large domestic market that remains essentially heavily protected against access to foreign competitors compared unfavourably with the smaller size of the domestic market in many countries, and the narrower scope for available domestic on-line feed to sustain the operations of international flag carriers in these

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<sup>8</sup> US President Jimmy Carter signed the International Air Transport Negotiations statement on 21 August 1978 (Presidential Documents 1978).

countries. Consequently, the extent of global competition in the industry has remained limited, particularly for international air services (Graham 1995).<sup>9</sup>

In response, various means were employed by airlines based in other countries to enhance their own international competitiveness in the long term. This included the movement towards privatisation of international airlines often in the wider context of domestic market deregulation, the liberalisation of non-U.S. bilateral treaties, and in some cases the formation of strategic alliances, mergers, and cross-ownership arrangements (Pustay 1992).

The trend towards free-market aviation economics associated with regulatory freedom and privatisation of firms and infrastructure had the objective of altering the competitive environment in which firms compete, and introducing structural changes in the global airline industry. These important changes can be examined in the alternative theoretical contexts of 'contestable markets' approach to the analysis of competition or the classical, Austrian and Schumpeterian analysis of competition.<sup>10</sup> Thus, depending on the theoretical framework adopted, the move towards free-market aviation economics is consistent with either the increasing contestability of airline markets or the enhanced process of competition in the industry.

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<sup>9</sup> The large size of the country, the large number of existing firms in the air transport market, the size of the customer base, etc. has meant that the United States is better able than most countries to promote domestic deregulation with little fear of hurting consumer welfare. It is not so obvious that complete reliance on the free market will work so well in other nations' domestic airline markets (Pustay 1992).

<sup>10</sup> Although the 'contestable markets' approach to the analysis of competition bears some elements in common with the classical, Austrian and Schumpeterian analyses of competition in the view that an industry may perform in a socially acceptable way even if it contains a very small number of firms, the origins of the 'contestable markets' approach lie much closer to the mainstream theory of industrial organisation, and rests upon more conventional analytical foundations (Davies 1992).

*The 'Contestable Markets' Approach to the Analysis of Competition in the Global Airlines Industry and Increased Market Power of Incumbent Firms*

The analysis of the impact of deregulation of the global airline industry within a 'contestable markets' approach to competition requires an examination of the changes in the competitive environment in the industry. As the route (or city pair) defines the basic unit of analysis of the competitive environment in the industry,<sup>11</sup> the market structure of the industry depends in part on the number of airlines operating between a certain city pair (which in some cases may be served by more than one airport).<sup>12</sup> The number of carriers was determined by governments prior to deregulation, but in markets that are no longer subject to large scale government regulation such as the United States since 1978, the number of carriers has since been determined both by the size of the market (i.e. the size of passenger traffic on a route in a certain period in relation to viable size of aircrafts) and a national element that has tended to limit competition. Such national element stems from the sustained dominance by carriers of two countries for flights between two international cities because of international regulation and consumer preferences. Consequently, airline routes are typically operated under conditions of oligopoly with the precise number of airlines tending to differ according to route (Ferguson, Ferguson & Rothschild 1993; Pryke 1987).

Although many airlines operate on routes where they face little competition, this has not implied the existence of substantial market power by these airlines if the route (or

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<sup>11</sup> Using the individual route as the basic unit of analysis of the competitive environment in aviation somewhat neglects the relatively newer concept of the airline as part of a network that seeks greater stability and profitability through the co-ordination of its activities within a wider geographical spread. This implies that the value of an individual route can be manipulated by internalisation into the wider network of an individual airline, and/ or alliance. The individual route as a basic unit of analysis has thus become less important than when the concept was first developed. For elaboration of the original concept of route-specific contestability, see Baumol, Panzar & Willig (1982), Bain (1956) and Caves (1962).

city pair) fulfils the requirements of a contestable market. The entry and exit conditions (the cost of offering a new route or to abandon an existing route) determine the contestability of the market in response to profit opportunities. In the absence of government-imposed entry barriers, airline markets are contestable to some degree, with the basic homogeneity of the service facilitating entry.<sup>13</sup> Conditions for a perfectly contestable market are, however, unlikely to be met because of some entry barriers such as those which result from cost differences arising from incumbent firms taking advantage of economies of scale and scope and density, or by congestion at particular airports which limit the facilities available for small and newly-established airlines.<sup>14</sup> Nevertheless, the contestability of unregulated markets in the airline industry has to some degree served to limit the market power of incumbent airlines and constrained their profit opportunities with positive knock-on effects on consumer welfare as prices are set at more competitive levels and consumers are allowed freedom of choice in their use of air carriers.<sup>15</sup>

In response to the underlying contestability of the unregulated market, the actions of incumbent airlines to gain and strengthen their market power by raising formidable barriers to combat the threat of entry are working against the aim of deregulation

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<sup>12</sup> The competitive environment is also affected by the extent to which alternative means of transport are close substitutes to air travel.

<sup>13</sup> In many deregulatory processes, it was assumed that airlines would be able to choose their routes optimally in the light of customer preferences and costs (Forsyth 1997).

<sup>14</sup> A perfectly contestable market is one in which entry is free, exit is costless, existing firms and entrants compete on equal terms and potential entrants are not deterred from entry by the threat of retaliatory price cutting by incumbents (Davies 1992). Economies of scale arise from an established network of connecting flights facilitating higher load. Economies of scope arise because passengers may find it convenient to make on-line connections by selecting one carrier as opposed to another.

<sup>15</sup> However, it should be noted that lower fares are often a result of price cuts by dominant carriers to prevent (mainly low-fare) independent carriers from obtaining and expanding competitive footholds in important routes and markets, rather than a result of more efficient operations (Brock 2000). Furthermore, the increased concentration of markets following deregulation (most notably in the United States where deregulation is at a mature stage) has, in effect, limited customer choices to below what it would have been in less concentrated markets with lower barriers to entry.

(Williams, 1993; Button, 1991) to create a more competitive industry.<sup>16</sup> Among these actions are:

- Predation in which an established carrier can manipulate the schedule of its own flights or to reduce price below cost to drive out or deter a new rival from entering the market;
- The ownership of a computer reservation system which favours established carriers;<sup>17</sup>
- The use of frequent flyer programmes (FFPs) by airlines with large route networks which provide opportunities for expanding the rights, amongst others, to free flights as well as offering a wider choice of destinations for these flights;<sup>18</sup>
- The relationships established with travel agents and customers;<sup>19</sup>
- Mergers with other domestically-based air carriers;<sup>20</sup>
- The protection of superior and dominating slots (availed widely through historical grandfather rights) of incumbent carriers in relation to allocation of take-off and

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<sup>16</sup> Existing carriers are regarded to have implemented a market leadership strategy (Ferguson *et al.* 1993).

<sup>17</sup> The founding rationale behind joint ownership by airlines of the major Computer Reservation Systems (CRSs) developed in the mid- to late 1980s was to raise the enormous financing required for the development and maintenance of such systems. However, with the competitive restructuring of the industry partner airlines within a common CRS have increasingly found themselves competing against one other in global alliances (Doganis 2001). This implies the diminishing priority of CRS ownership in the long run in favour of alternative means of distribution encompassing the needs of alliance operations.

<sup>18</sup> With the growth of importance of alliances, the impact of FFPs as a tool of product differentiation of the individual airline has declined in favour of the alliance as benefits can be used interchangeably by consumers between partner airlines. Paradoxically, this has enhanced the need for new tools of product differentiation of individual airlines comprising an alliance to entice passengers to fly with a specific airline over another partner on routes where alliance partners overlap. Thus, as partners of an alliance both co-operate and compete with one another, the global alliance systems of airline companies conform to the concept of "co-opetition" described by Nalebuff & Brandenburger (1996).

<sup>19</sup> Although still valid, the airline-agency and airline-customer relationship is currently being re-evaluated with the emergence of e-commerce and the need to review the high distribution costs airlines have been facing through the widespread use of agencies. In this respect, Doganis (2001) predicts a growing 'disintermediation' of airline distribution systems in favour of Internet and direct sales.

<sup>20</sup> This is particularly pronounced in the US domestic market where deregulation is at its most mature stage, and a vast national catchment area is prevalent. Development out of a strong domestic market is, however, also valid in other geographical home markets, such as the United Kingdom, Germany and France.

landing slots at congested airports, thus making it difficult for new competitors to gain access to airport resources;<sup>21</sup>

- Product differentiation as a means to counteract the destabilising impact of price competition in oligopolistic markets. By differentiating the features of the air travel service provided, and paying attention to the varying needs of particular categories of passengers, established airlines supported by advertising campaigns can counteract the basic homogeneity of the air travel service and gain a competitive edge by engendering a certain amount of customer and brand loyalty.<sup>22</sup>

The strategies of airlines of defending markets in the face of competition have increased the market power of incumbent airlines (the degree of which varies by route) and began in some cases to undermine the consumer gains from deregulation. Thus, while the expectations of a more competitive industry have been largely fulfilled in the initial period following deregulation in the United States, developments since the mid-1980s have been at variance with such expectations. The failure of new entrants to prosper meant that by 1990 the US market for air travel services had become more concentrated as 200 carriers of all sizes went out of business between 1978 and 1990, enhanced by the

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<sup>21</sup> In the United States, these goals have been achieved through a rigid build-up of dominant and exclusive hub-and-spoke systems leading to 'fortress hubs', thus reducing competition on many city pairs and impairing the development of point-to-point direct air services between cities. Major conflicts exist between strategies aimed at implementing more competitive airline industries and those concerned with providing airport capacity. These reflect the incompatibility of public support for the tariff, frequency and service advantages of airline competition and widespread opposition to the construction of new airport capacity, particularly runways. However, most importantly, liberalisation and deregulation of airline services increases markedly the demand for airport capacity in all its aspects.

<sup>22</sup> This includes the provision of unique privileges for business class air services, and other means of differentiation based on the characteristics of the aircraft and the flight. The process of product competition is increasingly internalised into the global alliance systems of airlines.

trend towards mergers between domestic air carriers.<sup>23</sup> Similarly in Europe, only the larger airlines such as British Airways and Lufthansa, experienced net gains from deregulation with their large size and ability to expand into new European routes in some cases through franchising and other forms of corporate alliances (Ferguson, Ferguson and Rothschild, 1993).<sup>24</sup>

Thus, within the analytical viewpoint of mainstream neo-classical theory the global airline companies based in the major industrialised countries — that lead each of the galaxy system of airline companies and thus comprise the core of international aviation alliances — are attaining a considerable degree of monopoly power over other airlines companies as a result of higher levels of industrial concentration after deregulation. The global airline companies can be regarded to possess *monopolistic* advantages that derive from the concept of barriers to entry to new competition of Bain (1954, 1956). These advantages enable global airline companies to exercise monopoly power or market power in final product markets.

*The Classical, Schumpeterian and Evolutionary Approaches to the Analysis of  
Competition in the Global Airline Industry*

While the ‘contestable markets’ approach to the analysis of competition has provided a useful insight in evaluating the impact of deregulation in the global airline industry, the approach is limited to the extent that the airline company is treated to be a “black box”— a reactive or passive product to the changes in the structure of the airline industry brought about by deregulation. The approach fails to account for the alternative

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<sup>23</sup> In the United States, the consolidation process has produced a group of four mega-carriers that in 1989 shared 90 per cent of the profits (Pustay 1992).



view of the firm as an institution with strategies and tactics, i.e. an active agent whose behaviour can cause changes in industrial concentration.<sup>25</sup> As seen in the previous section, the 'contestable markets' approach evaluates the impact of deregulation of the global airline industry based on changes in the competitive environment or market structure in the industry, and how this in turn affects the behaviour of firms comprising the industry. By contrast, the classical, Schumpeterian and evolutionary approaches would evaluate the impact of deregulation of the industry in terms of the changes in the strategies and tactics of the airline companies comprising the industry, and how this in turn affects the market structure of the industry.

In this context, two types of profitable airlines came into their own after deregulation and industry consolidation in the industry to include: major carriers operating global networks, and those carriers exploiting a particular niche market (Ferguson, *et al.* 1993). Each of these two types have adopted different strategies and tactics to sustain and promote their competitiveness in the midst of the deregulation, minimisation of regulatory controls, and privatisation in the global airline industry. Notwithstanding the legacy of higher unit operating costs and inappropriate fare and route structures, incumbent major air carriers based in core countries have prospered under deregulated markets by building on their market presence through fostering brand loyalty, extending their route networks and consolidating their position against new entrants. On the other hand, a large number of smaller and medium-sized regional feeder

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<sup>24</sup> For an extended discussion of the growth strategies adopted by the larger European carriers, see Doganis (2001).

<sup>25</sup> Such approach is theoretically opposed to the structure-conduct-performance paradigm in conventional or neo-classical industrial organisation theory in which the structure of the industry or market structure determines the conduct or behaviour of firms.

carriers based in some cases in developing countries have become dependent upon the major carriers in their role as traffic recipients and providers.

Despite the general trend towards deregulation and liberalisation in the global airline industry, the presence of remaining barriers to global competition has influenced greatly the strategies and tactics of profitable airlines in the industry. Infrastructure limitations and continuing government protection of national markets through bilateral ASAs and restrictions on foreign ownership of airlines are some of the powerful forces that inhibit the full realisation of global airline competition in the aftermath of the world-wide trend towards liberalisation in the industry. Even if these obstacles could be circumvented, the problem of fortress hubs remains as the principal mechanism through which mega-carriers seek to establish spatial monopoly. Thus, competition between airlines on both international and domestic scales remains a highly restricted process as external constraints compete with the peculiar characteristics of the airline industry (Graham 1995).

It is in light of the highly restricted process of competition in the global airline industry that airline companies have based their strategies and tactics. Taken within the context of Schumpeterian theory, some dynamic innovative airlines have fulfilled an entrepreneurial function through the introduction of "new combinations" in the provision of air services in light of remaining impediments to the process of rivalrous competition. The "new combinations" as a result of enterprise are manifested in the introduction of a new air service or of a new quality of an air service, the introduction of a new method of air service delivery, the opening of a new market, and the formation of a new

organisation of industry.<sup>26</sup> Apart from efforts in continual product differentiation, the most shining manifestation of the innovative strategy of some airline companies is the development of global market alliances since the mid-1980s (French 1997) as a means in which airline companies overcome the remaining constraints imposed by the current regulatory system (Debbage 1994) and infrastructure brought about by limited access to major hubs. By providing a more novel, multilaterally based solution to air service agreements away from restrictive bilateral ASAs, international aviation alliances are becoming an important determinant of both the market structure and the process of competition in the industry.<sup>27</sup>

Indeed, the emergence and evolution of alliances in the global airline industry has led to sweeping changes in the organisational mode of economic transactions in the global airline industry after deregulation. The organisation of the global airline industry encompassing both intra-firm and inter-firm relationships within and between airline companies has become the fundamental determinant of the competitiveness of airline companies as well as exerting important implications for the process of competition in the industry. The development of clusters or galaxies of firms linked not necessarily by ownership but by complex inter-firm relationships which have taken the form of quasi-integration has meant that competition is not defined between individual airline companies, but between organisational networks or corporate family constellations of

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<sup>26</sup> New markets are increasingly established through and as part of alliances, thus manifesting the increasing importance of individual airlines (of any size) as part of a network of inter-firm relationships. Thus, "new combinations" in the provision of air services are increasingly being undertaken between partners in a global alliance.

<sup>27</sup> Although a means of implementing "new combinations" in the provision of air services by airline companies, alliances are also a tool to increase their market power through joint operations and the lock-in of consumers into their networks, thus effectively limiting consumer choice. This is most notably displayed in 'beyond point-to-point' traffic on major routes as consumers requiring connecting flights are likely to be offered an online connection on the large carrier allied with the carrier serving their local destination. With

airline companies. As the galaxy system of airline companies is of different tiers, the position of airline companies within the tier (whether core, second/ lower tier or associate member) as well as the position of non-members in the galaxy system has important implications on the global competitiveness of individual companies.

Unlike the perspective of mainstream neo-classical theory, the global airline company at the core of the galaxy system of airline companies is treated in the classical and Schumpeterian approaches as an active agent whose behaviour to secure monopoly power — thorough innovation and knowledge creation and from the pursuit of higher profits from creating ‘new combinations’ in production (Schumpeter 1911) or new areas of social or productive capability (Cantwell 2001) — causes higher levels of industrial concentration. In this view, the global airline company possesses *competitive* advantages that derive from the concept of firms and entrepreneurs of unequal abilities of Schumpeter (1911, 1943) and Penrose (1959). Such competitive advantages — which enable the firm to create a quasi-monopolistic position for itself — derive from the differential ability of global airline companies to discover profitable opportunities, and not from the presence of monopoly power since the opportunities for profit accumulation are open to all firms (Tolentino 2000). Nevertheless, the process of rivalrous competition which requires freedom of entry (Kirzner, 1978) does not fully apply in the global airline industry where a plethora of non-market barriers blocking entry to potential competitors remain, despite recent trends in deregulation and liberalisation. Indeed, global alliance foundation alongside greater liberalisation at the domestic and international levels has created the paradox that enhanced competition — or the threat of increased competition

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such ‘beyond point’ competition and the lock-in of consumers, alliances can thus be redefined as tools of market power.

— has, in fact, led to higher industrial concentration.<sup>28</sup> Consequently, airlines retain varying degrees of market power even after deregulation (Ferguson, Ferguson and Rothschild, 1993).

## CONCLUSION

The paper sought to analyse the changes in the competitive position of airline companies in the global airline industry in the post-US deregulation era within the disparate perspectives in the theoretical economics of the firm. On the one hand, changes in their behaviour were examined within the mainstream neo-classical model of the firm in which the airline company is treated as a “black box”— a reactive or passive product to the changes in the structure of the airline industry brought about by deregulation. On the other hand, the airline company was also treated as an institution with strategies and tactics consistent with classical, Schumpeterian and evolutionary approaches, i.e. an active agent whose behaviour causes changes in industrial concentration. As the process of competition between airlines on both international and domestic scales remains a highly restricted process despite the general trend towards deregulation and liberalisation in the global airline industry, the paper finds that the neo-classical model of the firm still provides some explanation of some aspects of the changes in the competitive position of airlines in the global industry after deregulation. Nevertheless, the logical plausibility of the classical, Schumpeterian and evolutionary approaches is enhanced by their increasing empirical relevance and operational meaning in terms of contemporary business behaviour in the industry. A full understanding of the global airline company requires a

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For an extended discussion with reference to the US domestic market, see Brock (2000).

synthesis of the neo-classical, classical, Schumpeterian and evolutionary analyses of the firm.

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# **AIRPORT PAVEMENT MANAGEMENT**

by

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## **ABSTRACT**

Airport pavements are extensive and constitute significant infrastructure supporting air transportation. With considerable growth in air transportation, preserving, improving, and expanding airport infrastructure, including pavements, have become more important and necessary. Thus, there is emphasis on Airport Pavement Management System (APMS). APMS have evolved from a concept to a coordinated, integrated, responsive, and implementable system. The development of technologies such as CAD, GIS, GPS, remote sensing, and multimedia tools have potential to considerably improve APMS. The paper first discusses the concept and need for APMS and various pieces of Airport Pavement Management Information (APMI). The paper next examines the differing characteristics and needs for APMS at commercial airports and general aviation airports. Finally, the paper discusses the emerging issues related to airport pavement management and the opportunities that exist in developing adequate, reliable and appropriate APMI and in making APMS integrated and responsive using emerging technologies and system methodologies.

**Key words:** Airport pavement management system (APMS), Airport pavement management information (APMI), Commercial Airports, General Aviation Airports, Information Technologies

## **1. INTRODUCTION**

Airport infrastructure is extensive and varied and is operated and financed differently by different entities or agencies in the U.S. and worldwide. In the U.S. there are over 18000 airports, of which around 3500 are part of National Plan of Integrated Airport Systems (NPIAS) with over 500 providing commercial service, over 300 serving as reliever airports, and over 2400 used for general aviation (GA) purposes (Wells, 2000). The busiest commercial airports have handled up to 75 million passengers (e.g. Atlanta's Hartsfield), up to 900000 operations (e.g Chicago-ORD), and up to 2.5 million metric tons of cargo (e.g. Memphis International Airport). The nation's air traffic delay problems are concentrated at the large hub airports, which impacts airport pavement management activities--from data collection to maintenance to rehabilitation to reconstruction.

Demand for air transportation has continued to increase since deregulation. Maintaining and improving such infrastructure is a necessity and a challenge to provide adequate capacity, ensure safety and increase efficiencies. Airport pavements form the most critical asset of an airport. In the United States, approximately \$ 2 billion per year is being spent on construction and rehabilitation of airport pavements under the airport improvement program (AIP) (McNerney, 1995; Ollerman and Varma, 1998). In addition, there are millions of dollars being spent on maintenance. Federal support is not available for maintenance. The preservation of large infrastructure investments at airports through cost-effective pavement maintenance and rehabilitation is a major goal for airport authorities and municipalities operating general aviation airports.

Airport Pavement Management System (APMS)(s) have been established in many of the major airports in the United States and have proven to be very useful and cost effective for the municipalities and airport authorities involved. APMS has been implemented in some airports and also at statewide level in the United States. Various agencies, states, and institutions have realized the merits of visualizing the information used, derived, and produced by facility management systems, including APMS.

This paper looks into the differing characteristics and needs for APMS at commercial airports and general aviation airports. Over last couple of decades attempts have been made to develop integrated and responsive APMS. The development technologies such as CAD, GIS, GPS, and multimedia technologies have fostered development of considerably improved APMS. The paper discusses different perspectives related to development of integrated and responsive APMS at commercial airports and at statewide level for general aviation airports.

## **2. AIRPORT PAVEMENT MANAGEMENT SYSTEMS (APMS): CONCEPT AND NEED**

A proper maintenance and rehabilitation program can potentially extend the serviceable life of the pavement. APMS should not interfere with or replace good pavement design, materials, rehabilitation, or other activities. The system is there to coordinate these activities for maximum pavement life and benefits (Hossain and Uddin, 1996).

The identification of airport maintenance and rehabilitation (M&R) needs is a continual process. Most airports in the U.S. were built after World War II, and many of the records from their initial construction no longer exist. Most of these airports have been modified since their initial construction for many reasons, including increased traffic, larger and heavier aircraft, and safety considerations. Historical records of these modifications and other activities, including M&R, are usually available, but may be stored in many different locations. The need for these records to be collected and organized into a database for an airfield was realized and emphasized over two decades ago (Arntzen, 1978).

A generalized framework for a total APMS is shown in Figure 1. Such a system can ideally provide information for programming, planning, budgeting, design, construction, maintenance, rehabilitation, research, field studies, and decision making. Analytical and statistical models, procedural or logical framework, or a set of decision rules may be utilized in conjunction with the database to provide the requisite information. The various activities in an APMS can be categorized into the network level and the project level. The network level can be further divided into the project selection level and the program level (Haas, Hudson, and Zaniewski, 1994). The project selection level involves prioritization to identify which projects should be carried out each year of the program period. At the program level, budgets are established and general fund allocations made over an entire network. APMS at the project level deals with technical concerns, such as detailed design decisions, for an individual project. Decisions at each level must interface with one another. APMS rationalizes need for maintenance activities in technical and economical manner and in a way is proactive way to protect substantial investment. The four basic elements common to all pavement management systems are a database, a pavement analysis method, a M&R assignment method, and a method for the displaying of results.

APMS results in efficient utilization of limited resources and can be instrumental, if designed and updated properly, in qualifying, quantifying, combining, and communicating information about condition of infrastructure, improvement needs at different scales, and consequences of allocating budget for maintenance. This could lead to improved decisions regarding prioritizing maintenance needs, establishing reconstruction projects, and better utilization of budgets. Much emphasis has been on condition assessment and related data collection, tests and analyses. A total APMS consists of a coordinated set of activities, all directed toward achieving the best value possible for the available funds in providing and operating smooth, safe, and economical pavements. A total APMS may serve different management needs or levels, and it must interface with broader management systems (e.g. facility management systems) (Varma, 1993; McNerney, 1995).

### **3. AIRPORT PAVEMENT MANAGEMENT INFORMATION (APMI)**

A listing of the types of APMI is shown in Table 1. It should be noted that development and use of all these types of information may not be possible or even relevant for a given airport. The scope of pavement management (network versus project level or commercial versus general aviation) should be understood before developing and using such information.

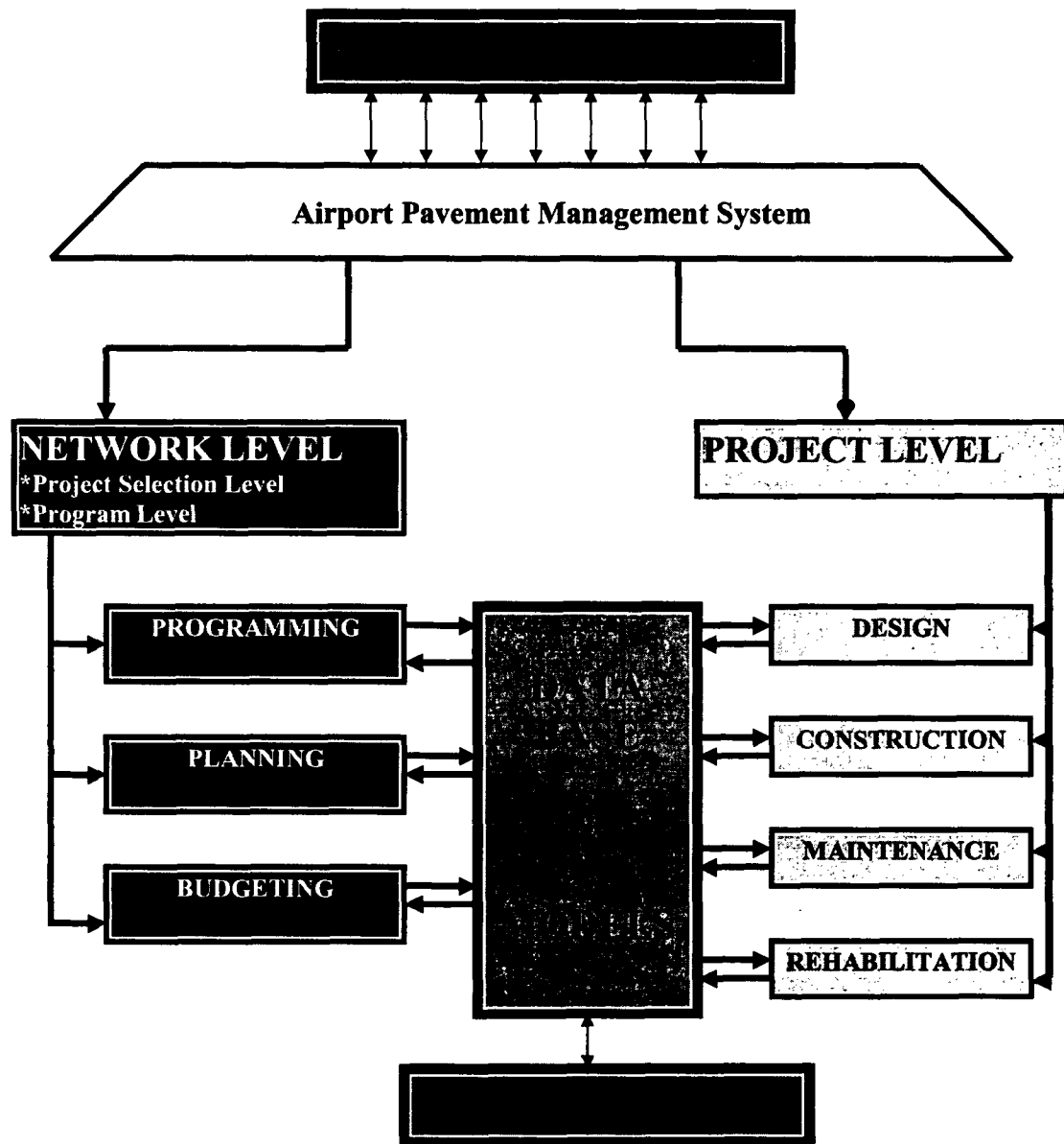


Figure1. Generalized Framework for an Airport Pavement Management System  
 (Source: Adapted from Haas, Hudson, and Zaniewski, 1994)

**Table 1. Types of Airport Pavement Management Information**

<b>CLASSES</b>	<b>TYPE OF INFORMATION</b>
<b>PLANNING</b>	<ul style="list-style-type: none"> <li>• Socioeconomic Characteristics</li> <li>• Air Travel Demand</li> <li>• Aircraft Fleet Mix, Volume, Operations</li> <li>• Multimodal &amp; Intermodal Considerations</li> </ul>
<b>LOCATION</b>	<ul style="list-style-type: none"> <li>• Geographic Location</li> <li>• Climate</li> <li>• Relevance in NPIAS</li> </ul>
<b>DESIGN</b>	<ul style="list-style-type: none"> <li>• Design Aircraft Characteristics &amp; Operations</li> <li>• Geometric Design—Layout, Size, Shape</li> <li>• Structural Design—Material, Thicknesses</li> <li>• Drainage and Safety Design Features</li> <li>• Design Life</li> </ul>
<b>CONSTRUCTION</b>	<ul style="list-style-type: none"> <li>• Date and Type of Construction</li> <li>• Drawings &amp; Specifications for Construction</li> </ul>
<b>INSPECTION &amp; TESTING</b>	<ul style="list-style-type: none"> <li>• Sections and Samples—Unit and Size</li> <li>• Pavement Condition Index (PCI) Data—Types, Levels, and Quantities of Distresses</li> <li>• Non-Destructive Testing Data</li> <li>• Runway Profiles and Surface Friction</li> </ul>
<b>CONDITION ANALYSIS</b>	<ul style="list-style-type: none"> <li>• Section PCI</li> <li>• PCI Remaining Life</li> <li>• Structural Damage Analysis</li> <li>• Vertical Acceleration Analysis</li> <li>• Surface Friction Analysis</li> </ul>
<b>CONDITION PREDICTION</b>	<ul style="list-style-type: none"> <li>• Deterioration Curves—Functional Remaining</li> <li>• Structural Remaining Life</li> <li>• Vertical Acceleration Trigger</li> <li>• Surface Friction Trigger</li> </ul>
<b>MAINTENANCE &amp; REHABILITATION</b>	<ul style="list-style-type: none"> <li>• Repair Strategies for Different types, levels, and quantities of Distresses</li> <li>• Impact of the Strategies on PCI</li> <li>• Timing of Repair Strategies</li> </ul>
<b>COST</b>	<ul style="list-style-type: none"> <li>• New construction, maintenance, rehabilitation, user, agency costs</li> </ul>
<b>MANAGEMENT &amp; INSTITUTIONAL</b>	<ul style="list-style-type: none"> <li>• Budget Conditions &amp; Constraints</li> <li>• Priority Policy</li> <li>• Stakeholders and Users of the System</li> <li>• Economic and other Impacts of the Improvement Plans</li> </ul>

All pavements at each airport need to be divided into homogeneous sections and assigned a section number. Areas are considered homogeneous with respect to function, age, composition, and condition. These section numbers are used as an index for accessing, storing, updating, and retrieving purposes in a relational database of an APMS. Sections do not need to be adjacent; several separate sections that possess homogeneous attributes can be assigned the same section number. The entire airport pavement needs to be divided into homogeneous sections and categorized on the basis of type, use, and condition of the section. It is important to divide airport pavement into homogeneous regions for analytical purposes also. Similar pavements deteriorate at similar rates (Shahin et al., 1986). Inspection procedures also require this type of division of pavement before inspection (FAA, 1982). Most airports in the United States that have already been inspected, have previously divided their pavement for this inspection procedure, and have permanently marked these sections so the same section boundaries are used during each inspection. The functional condition of the pavement is usually determined by Pavement Condition Index (PCI) according to FAA Advisory Circular AC 150/5380-6 (FAA, 1982). The basis of this determination is a visual inspection, which involves identifying the location, type, and severity of any distress found in the pavement. The pavement sections are further divided into sample units for ease of inspection as well as database development. Random areas are inspected, and an overall PCI is determined for the section.

The maintenance records in the database need to reflect the locally preferred method of maintenance for a given distress. These records can show trends in future maintenance activities based upon previous budget allocations. Maintenance and rehabilitation (M&R) priorities can also be stored in this section simply by setting the minimum acceptable PCI level for a given type of facility. Current cost figures are necessary to enable the evaluation of M&R strategies on an equal basis. These data should be in a unit cost format to facilitate calculations and should be updated periodically to reflect changes in the economy. It should be noted that mobilization fees for smaller activities may raise the unit cost for some smaller M&R activities.

APMI could be developed by data collection efforts using observations, devices, surveys, and responses. In addition, APMI can be established from published data and information sources, planning documents, design documents, construction drawings and specifications, guidelines from FAA and other relevant agencies, statistical or analytical methods, expert judgment, CAD tools, procedural or logical framework, and/or a set of decision rules.

The data requirements for an APMS are rather extensive and require the development of an organized database. The implementation of an APMS requires an initial database that includes present pavement condition, construction dimensions, and historical information concerning maintenance activity and current and past traffic levels (McGhee, 1990). The initial inventory will involve a detailed examination of all records and plans concerning design, construction, inspection, maintenance, and rehabilitation. These records need to reflect everything known about the airport and to locate pavement sections relative to each other. However, this is inefficient with the current APMS. The data provided by these records will help to determine the serviceable life of the pavement and will also help to identify chronic problem areas. Records need to be easily accessed, allowing airport personnel to quickly familiarize themselves with all available data pertaining to any section of the airport.

Visual inspection is the oldest and most common method of pavement condition evaluation. The biggest problem with conducting a visual inspection is the subjective nature of the process. It is quite possible that two people may have different opinions as to the condition of a single section of pavement. Moreover, an inexperienced inspector may provide an inaccurate assessment of the distress level and severity. The pavement inspection procedures, as outlined in FAA AC/5380-6 (FAA, 1982), were introduced to provide a standard method for condition evaluation and to minimize subjectivity to some extent. The method for determining PCI using the visual inspection is well-established (FAA 1982, Eckrose and Green 1988). There are manuals for visual or field inspection of pavements (Shahin 1989a, 1989b; Eckrose and Green, 1988). Visual inspection is the chosen method for determining the pavement condition at GA airports and low volume commercial airports due to the ease of inspection, the light traffic levels, and the light wheel loads.

The PCI method was developed by the U. S. Army Corps of Engineers for use by the U. S. Air Force to determine the condition of military airfields and has been adopted for use at civilian airports by the FAA. The PCI inspection is also the recommended pavement inspection procedure of the American Public Works Association for use in municipalities (Eckrose and Green, 1988). Several other methods for collecting condition information about airport pavement have been tried, but they are more time-consuming and expensive and are generally reserved for use in high traffic and loading conditions. These methods include non-destructive tests such as falling weight deflectometer (FWD) tests, ground penetrating radar (GPR) and infrared thermography, and destructive tests such as coring (Bush, 1980). In addition, for heavy concrete pavement section Heavy Weight Deflectometer (HWD) has been used, as was the case for new Hong Kong airport, Chek Lap Kok (Dynatest, 2001).

Inspection of all the pavement in a section is not considered necessary; visual inspection is conducted on a select number of samples of each pavement section. The goal of sampling is to assess the types, magnitude, and levels of distress present in the system without inspecting the complete system. To this end, two confidence levels are recommended for sampling: project and network levels. Project confidence level is 95% and is determined statistically during the inspection. Project level confidence is used to determine the extent of distresses when analyzing specific projects to be performed. It is generally used for major commercial airports. A network confidence level is used in statewide systems and usually involves the inspection of 15 to 25% of pavement at large airports and 25 to 35% at smaller airports (Eckrose and Green, 1988).

There are 15 different types of distress in rigid pavement and 16 for flexible pavement (see Table 2). These 31 different distresses combine with four different severity levels to create 81 distresses. There are distinct methods to calculate quantities for each of these pavement flaws. It is very important to identify the different distresses correctly because each distress has a different remedy; and to be cost effective, the correct rehabilitation needs to be applied in each case. Severe block cracking in flexible pavement looks similar to alligator cracking. Block cracking is an effect of the age of the pavement while alligator cracking is a load-related distress. In rigid pavement, a corner break may look similar to corner spalling. Corner breaks are a result of loss of support and are load related, whereas spalling results from excessive stresses at the joint or crack caused by the infiltration of incompressible materials.



**Table 2. Distress Types and Levels**

<b>Distress types</b>			
<b>Distress #</b>	<b>Flexible pavement</b>	<b>Levels*</b>	<b>Causes</b>
41	Alligator cracking	A	Load
42	Bleeding	B	Material
43	Block Cracking	A	Age
44	Corrugation	A	Construction
45	Depression	A	Construction
46	Jet Blast	B	Use
47	Joint Reflection	A	Material
48	L & T Cracking	A	Load
49	Oil Spillage	B	Use
50	Patching	A	Repair
51	Polished Aggregate	B	Age
52	Raveling/Weathering	A	Age
53	Rutting	A	Load
54	Shoving	A	Climate
55	Slippage Cracking	B	Load
56	Swell	A	Construction
<b>Rigid Pavement</b>			
61	Blow-up	A	Climate
62	Corner Break	A	Load
63	L-T-D Cracking	A	Load
64	"D" Cracking	A	Climate
65	Joint Seal Damage	A	Age
66	Small Patching	A	Repair
67	Large Patching	A	Repair
68	Popouts	B	Material
69	Pumping	B	Construction
70	Scaling, Map Cracking, Crazing	A	Material
71	Settlement/Faulting	A	Construction
72	Shattered Slab	A	Load
73	Shrinkage Crack	B	Construction
74	Joint Spalling	A	Construction
75	Corner Spalling	A	Construction
* Type A: High, Medium, or Low Severity    Type B: No Severity Level			

Source: FAA, 1982; MicroPAVER, 1997; CERL, 1996

Minimum PCI levels needs to be determined for each APMS system. This is a subjective decision. It is not feasible to expect all pavement sections at an airport to have a PCI greater than 80. The first time a M&R plan is developed with this type of expectation, the monetary needs for the following year may be greater than the facility's budget for the next 20 years combined. The correct method is to perform the inspection and determine reasonable goals for the facility. Generally, the minimum PCI for runways is five points greater than for the taxiways and ten points greater than for the apron sections. The initial goal for a section may be to achieve a PCI as low as 50. In time, these goals can slowly be increased as the facility's overall condition improves.

Predictions of the future condition of airport pavements can be accomplished through a careful examination of all aspects of a section of pavement. The condition history of similar sections of

pavement helps in the development of their deterioration model. A comprehensive inspection to determine the types of distress a pavement is being subjected to can help to select the optimal rehabilitation technique. Determining the current condition of airport pavement has become a systematic process, but there is a great deal of debate about determining of the future condition of the pavement. Determining the rate of deterioration is important, yet it is very difficult due to the complex nature of pavement deterioration. There is a lot of research underway to determine the rate of deterioration for both highway and airport pavements. Highways and busy commercial airports usually experience load-related pavement deterioration, while general aviation airports experience age-related deterioration. Forecasts of pavement conditions combined with minimum desired conditions will determine the optimal time for rehabilitation. The optimal repair time is the point at which deterioration begins to increase at a faster rate. Higher M&R costs will result from excessive deterioration if the pavement is not repaired at this point (Brotten and McNeely, 1995). Analysis of alternatives involves the knowledge of the optimal repair time, current construction costs, future maintenance costs, and present and future budget availability. It also involves the knowledge of the structural condition and life expectancy.

#### **4. APMS AT COMMERCIAL AIRPORTS**

APMS(s) have been established at O'Hare International Airport (Brotten et al., 1995, 1996; Schwandt, 1996), Dallas-Fort Worth (DFW) International Airport (Larry and Soule, 1991), John F. Kennedy International Airport (Rada et al., 1992, 1995; Schmerl, 1992; Schwartz et al., 1991). These systems have proven to be very useful and cost effective for the municipalities and airport authorities involved. The airport authorities at O'Hare International Airport in Chicago compared the recommended action for a section of runway with the installed APMS to the action they would have taken if they did not have the system in place and found they saved several million dollars (Schwandt, 1996). The Port Authority of New York and New Jersey (PANYNJ) has control over three airports: John F. Kennedy International Airport, Newark International Airport, and LaGuardia Airport. PANYNJ has implemented a Geographic Information System (GIS)-based APMS for the three airports, which has enabled them to predict future pavement performance and conditions to make better budget forecasts (Schmerl, 1992). Much of the implementation is basically based on the PAVER methodology. Orlando International Airport, because of its airport-wide integration of CAD and GIS data, provides a very good example for developing GIS-based APMS (McNerney, 2000).

Realizing the importance of having comprehensive information about airport infrastructure in general and airport pavements in particular several new airports of the 1990s and 21<sup>st</sup> Century have embarked and invested on extensive data collection regarding location, characteristics, and conditions of airport infrastructure. For example, Dynatest, Inc was involved in collecting information for the new Chek Lap Kok (CLK) airport in Hong Kong. This airport contained 1.7 million square meters of flexible pavement for the 3.8 km runway 25L/07R and the 28 km taxiway system, 0.4 million square meters of concrete block pavement, and 0.7 million square meters of rigid pavement. Heavy Weight Deflection (HWD) testing was carried out. Prior to its opening in July, 1998, the Hong Kong Authority contracted to collect PCI data to determine the baseline surface condition, profile and roughness data, and deflection data. Dynatest in 1997 developed, based on their extensive experience in highways, the software A.I.R.P.O.R.T.S and

Performance and Economic Rating System (PERS) to deal with airport pavement management (Holt, 1999). The system was developed to address the deficiencies that existed then--PCI was not part of modeling process, maintenance projects were not integrated fully, airports did not collect roughness/profile data, user costs was not a consideration, and delay costs were not used to evaluate rehabilitation alternatives at airports. The AIRPORTS system allows user to monitor the value asset over time and under different budget scenarios and also enables them to determine optimal budget. PERS is integral and crucial part of AIRPORTS and utilizes an incremental-recursive model for calculating pavement performance.

In close cooperation with Copenhagen Airports RAMBOLL has developed AIRPAVE MANAGEMENT, a windows-based APMS (Ramboll, 2001). The system facilitates systematic and optimum maintenance of pavements and estimates needs for future. It consists of three modules: a management information system (MIS), a pavement management system (PMS), and a geographic information system (GIS). AIRPAVE MANAGEMENT has been implemented in Copenhagen Airport and is used for maintenance planning of the airport's pavements, approximately 3 million square meters.

Some key issues have been recently associated with pavement management at busy commercial airports. Fatigue of airport pavements is an important consideration in the analysis and management of high-traffic pavements at commercial airports. The current PCI method of pavement evaluation does not adequately evaluate fatigue cracking of airport pavements as shown with inspections from Hartsfield International Airport and DFW International Airport (McNerney and McCullough, 2000). The suggestion from this research was geographic mapping of distresses by distress type, which can be best accomplished in GIS.

Also, a full cost approach to airport pavement management should not be limited to agency costs but should include delays associated with disruption of operations and user costs (McNerney and Harrison, 1995). In addition, information from APMS can be very useful for construction planning and scheduling. Moreover, the environmental costs of pavement management should also be integrated. GIS, as a platform, can serve well to integrate these additional considerations into APMS. Furthermore, PAVER, developed in 1970s and subsequently updated, has not kept well with addressing management of pavements at commercial airports serving larger and heavier aircraft. There is a need to go beyond PCI-based approach.

## **5. APMS AT GENERAL AVIATION AIRPORTS**

Communities that do not receive scheduled commercial service may be included in NPIAS as sites for general aviation aircraft if they account for enough activity (usually at least 10 locally owned aircraft) and are at least 20 miles from the nearest NPIAS airport. General aviation airports tend to be distributed on a one-per-county basis in rural areas. The airports serving general aviation are varied. Typically, they are small, usually with a single runway and only minimal navigation aids. A few GA airports located in major metropolitan areas (e.g. Van Nuys, Long Beach) handle extremely high volumes of traffic (particularly business and executive aircraft) and are busier and more congested than all but the largest commercial airports. General aviation fleet does include transport-type equipment similar to that used by major airlines, over 70 percent of GA aircraft are single-engine piston aircraft.

General Aviation (GA) airports are owned by a municipality that decides how the airport will develop, expand, and operate. All airports within a state compete for limited federal grant money for construction improvements (Green and Scherling, 1994). Historically, M&R of airport pavement have been undertaken when an airport sponsor requested funds for improvement. These requests were usually not made by an engineer, occasionally were not the correct maintenance procedure, and were generally requested well before or long after they should have been implemented ( Broten and McNeely, 1995). Various states have recognized the need to evaluate the condition of the airport pavements, to determine the needed improvements, and to evaluate them on a priority basis.

Most general aviation airport pavement deterioration are age (or environment) related. A very comprehensive study on GA airport longevity trends have been conducted recently in Illinois (Van Dam and Bildilli, 1996; Van Dam et al., 1994, 1995). This study dealt with concepts and practices for considering GA airport pavement performance and longevity.

The concept of systematic and comprehensive maintenance program for the airports on a statewide basis gained acceptance in 1980s and development of APMS for GA airports started in 1990s. APMS has been implemented on a statewide basis in Texas (Freeman and Dresser, 1993), Virginia (Broten and McNeely, 1993), Florida (Green and Scherling, 1994; Scherling, 1996), Arizona (Holt et al., 1994), North Carolina (Walston, 1996), Kansas (Hossain and Uddin, 1996), and North Dakota (KLJ, 2000). Most of these are network-based APMS. The Kansas system presents condition information on basis of PCI (used by U.S. Army's Corps Engineer's PAVER) and on basis of Pavement Classification Number (PCN), which is used by International Civil Aviation Organization (ICAO) and accepted by FAA for all airports. The North Dakota system is GIS-based and uses ESRI's ArcView software along with analytical models developed by Eckrose and Green. An object-oriented language program was used to develop an interface between Arcview and the PMS models. The major benefit of Texas, Arizona, and Florida system has been collection and storage of historical records in a centralized database which is easily accessible. Since FAA recommended MicroPAVER most of the systems have been based on that; North Dakota system is an exception in that it uses the software developed by Eckrose and Green and is linked to GIS. AirGIS Pavement Management Application (PMA) allows the user greater opportunity to visualize and understand the airport runways, taxiways, and other facilities with their capabilities, condition, and life expectancy through use of digital maps, charts, and aerial photography (KLJ, 2000).

## **6. INTEGRATED AND RESPONSIVE SYSTEMS--ISSUES & PERSPECTIVES**

The system used for NY/NJ Port Authority and Kennedy International Airport (Rada et al., 1992) and O'Hare International Airport (Broten et al., 1996) are examples of integrated system at a commercial airport. Among the general aviation APMS in Virginia (Broten and McNeely, 1995) is the most integrated and responsive. The integration of analytical components of APMS has evolved over the past two decades. However, typically there is no good documentation on the different types of information that are used by, developed within, and produced by the APMS. The information that is produced is in the form of computer outputs containing text, numbers, and graphical plots. It is difficult to understand, interpret, and visualize the information used to

finally evaluate and recommend a M&R plan primarily based on the paper outputs. Realizing this impediment, several pavement management systems, including some APMS, have been interfaced with multimedia systems, viewing systems, or GIS (Shahin et al., 1997; Schwartz et al., 1991; Green and Scherling, 1994; Holt et al., 1994; McNerney, 1995; Ollerman and Varma, 1998). Various agencies, states, and institutions have realized the merits of visualizing the information used, derived, and produced by facility management systems, including APMS. A detailed examination of the issues related to what APMS needs to be visualized, why it needs to be visualized, and how it should be visualized has been documented recently (see Ollerman, 1998; Ollerman and Varma, 1998).

The task of airport pavement management increases considerably in magnitude and complexity as we go from one airport to multiple airports. The criteria for evaluating the importance of different types of repairs to be undertaken with the limited budget becomes one of the most challenging tasks. Such a challenge should be met by understanding the relative importance of the various pavement sections at various airports as well as the viewpoints and needs of the various stakeholders.

Pavement management saves money through effective use of available resources and funds, not through the reduction of an airport's budget. More money may be available because the airport manager will be able to better justify the needs of the facility to the funding agency. Benefits of APMS will be seen through overall increased pavement serviceability, increased use, and improved credibility. APMS is a tool that may be used to fight budget battles (Bremer, 1998). It provides a basis for capital improvement program and can show the relative condition of the airport at present and possibly in the future. The FAA has determined the total annual cost to maintain or rehabilitate a relatively poor pavement may be four to five times the cost of maintaining a pavement in relatively good condition (Horonjeff and McKelvey, 1994).

A PCI of 100 is generally accepted as an initial PCI level, and average yearly deterioration is the figure we need to determine. There are usually several curves; specifically, curves are created for PCC, AC, AC overlay, and PCC overlay pavements. In statewide systems, there may be more curves according to the differing soil and climatic conditions. The graphs created do not usually provide a straight-line graph, and some manipulation is required. Old pavements in good condition and new pavements in poor condition are usually moved to a different or new group for analysis.

Some of the methods for finding the deterioration rate line are straight line extrapolation, regression\empirical, mechanistic-empirical, polynomial constrained least square, S-shaped curve, probability distribution, and Markovian decision models (Hossain and Uddin, 1996). Some pavement management programs also involve the use of predetermined curves. Development of appropriate performance and deterioration curves have been the area where the majority of airport pavement research has been focused (Monismith, 1978; Seiler et al., 1991; Shahin et al., 1987; Witczak, 1978; Van Dam and Bildilli, 1996; Van Dam et al., 1994, 1995; Zimmerman and Broten, 1996). Pavements deteriorate due to aging, climatic effects, traffic loading, material defects, or a combination of these. Typically, the pavement performance and deterioration curves are in terms of Pavement Condition Index (PCI) and age of the pavements.

Forecasting the future condition of pavement involves knowledge of the age and performance of pavement of the same type. This information is necessary in determining the remaining life of the pavement and in identifying possible future M&R needs. An example of this could be checking the history of the airport and discovering that all asphalt pavements have been seal-coated within three years of construction. Therefore, it would be reasonable to expect an asphalt pavement constructed this year will need to be seal-coated within the next three years. Pavement analysis also involves evaluating pavement distress and determining the optimal repair technique. Repair strategies are determined by the dominant distress in the pavement and while some may be performed independently, some are mutually exclusive (Holt et al., 1994).

There needs to be an extra emphasis on clearly identifying the types, use, and development of airport pavement management information. Despite such integration, there is still considerable difficulty faced by users and analysts in being able to clearly communicate the interpretation and significance of the numerous outputs produced by such models. Such communication can be facilitated by effective visualization of APMI. Toward this goal, some efforts have been undertaken to integrate GIS into APMS (Shahin et al., 1997; Schwartz et al., 1991; Green and Scherling, 1994; Holt et al., 1994; McNERney, 1995; Ollerman and Varma, 1998). Such integration is perceived to provide great flexibility and capability concerning information analysis, storage, retrieval, and data output and display.

The continuing growth in the computer-aided drafting and design (CADD), GIS, and other graphic and multimedia systems is responsible for the increased interest in visualization. The extent, coverage, and complexity of transportation infrastructure have made the task of managing such facilities a challenge. The variety and quantity of information needed to design, operate, maintain, and manage the infrastructure necessitate a team approach and require use of numerous computer-based tools. As computers have become more common and more accepted, a variety of visual displays has been devised to help people to quickly evaluate and assimilate information (Landphair and Larsen, 1996). The simplest graphic tools are charts and graphs that show the relationships between two or three different variables at the same time. An even more powerful device is the thematic map produced from a GIS which places multiple sets of information in 2- or 3-dimensional space and displays the relationships among the various components.

The major deficiency is the inability to effectively communicate the wide variety of information available from an APMS. Sorting through the large amount of APMI available for an airport network (or even an airport) can be a monumental task. The information is in inspection, construction, maintenance, and budget reports. The information also includes information on construction plans, maintenance priorities, and forecast of pavement conditions and work plan. All or some of this information needs to be communicated to the people associated with the airport system. In addition, there is a need to report and represent this information within the spatial context of the airport pavement infrastructure. The need can be addressed by tying the spatial representation or entities with the associated APMI.

Communication is the most important reason to visualize APMI. All of the information collection, organization, analysis, and compilation will be a waste of time, money, and resources if the conclusions cannot be presented to those who need to understand and use them. Visualization is the best method for communicating the information. Current presentations are

using CAD drawings for selected features and scenarios. This process is tedious and not repeatable or amenable for easy updating.

Visualization of APMI allows the viewer to quickly grasp concepts. Visualization can provide a map, color-coded for PCI, showing the location of all the pavement sections (see Figure 2) and the relative condition of each. The map can convey the PCI of each individual section, sections that are in better condition than others, and the size of each section. Visualization allows comparison of the different attributes of pavement sections to each other. This can be used to great advantage in airport management. It allows an airport manager or engineer to understand what attributes pavement sections may have in common with one another. This concept is important in understanding why one section of pavement is deteriorating more rapidly than other pavement sections.

In this era of rising costs and tightening budget, it is very important for a budget committee to understand the effects of different budget scenarios upon the pavement condition of the airport. The concept and consequence of deferred maintenance is important to impress upon the people responsible for allocating money for airport pavements. Visualization can show a funding agency how budget reductions and the need of additional funds will affect the pavement condition in the future.

The types of information to be visualized will differ from one user to another. The major groups of people who need APMI are airport network administrators, budget committees, airport managers, airport engineers, airport maintenance personnel, and others. Each group needs to see different information about the airport pavement to effectively do their job. Some groups will need to see the same information, but in a different manner.

The visualization needs can be addressed through use of CAD programs, graphical packages, multimedia systems, viewing systems, and GIS. The level of complexity of the airport systems and the corresponding APMS and APMI will determine the appropriateness of the mechanism. For a project level APMS, a CAD program may be sufficient to provide the needed visualization. However, for project selection level and program level, the use of CAD programs, graphical packages, multimedia systems, and viewing systems may not be sufficient or efficient. One of the key reasons is the need for tying the APMI with spatial aspects of airport systems. Moreover, the ability to query and update is not easily and efficiently available in systems other than GIS.

GIS is designed to manage geographically referenced information. It can efficiently capture, store, update, manipulate, analyze, and display spatial data in a variety of ways to achieve the desired result (Clarke, 1997; Star and Estes, 1990). GIS environment provides a structured, systematic process for quickly conveying APMI and can be utilized to illustrate the effects of a number of scenarios to users. It should be noted that this paper has not explored all the possibilities and capabilities of a GIS. Schematic of a generalized architecture of a system for seamless integration of APMS and GIS is shown in Figure 3. Efficiencies can be achieved if an APMS is interfaced with a GIS. The querying capability and much easier updating of the various views are the added advantages of a GIS-based visualization of APMI.

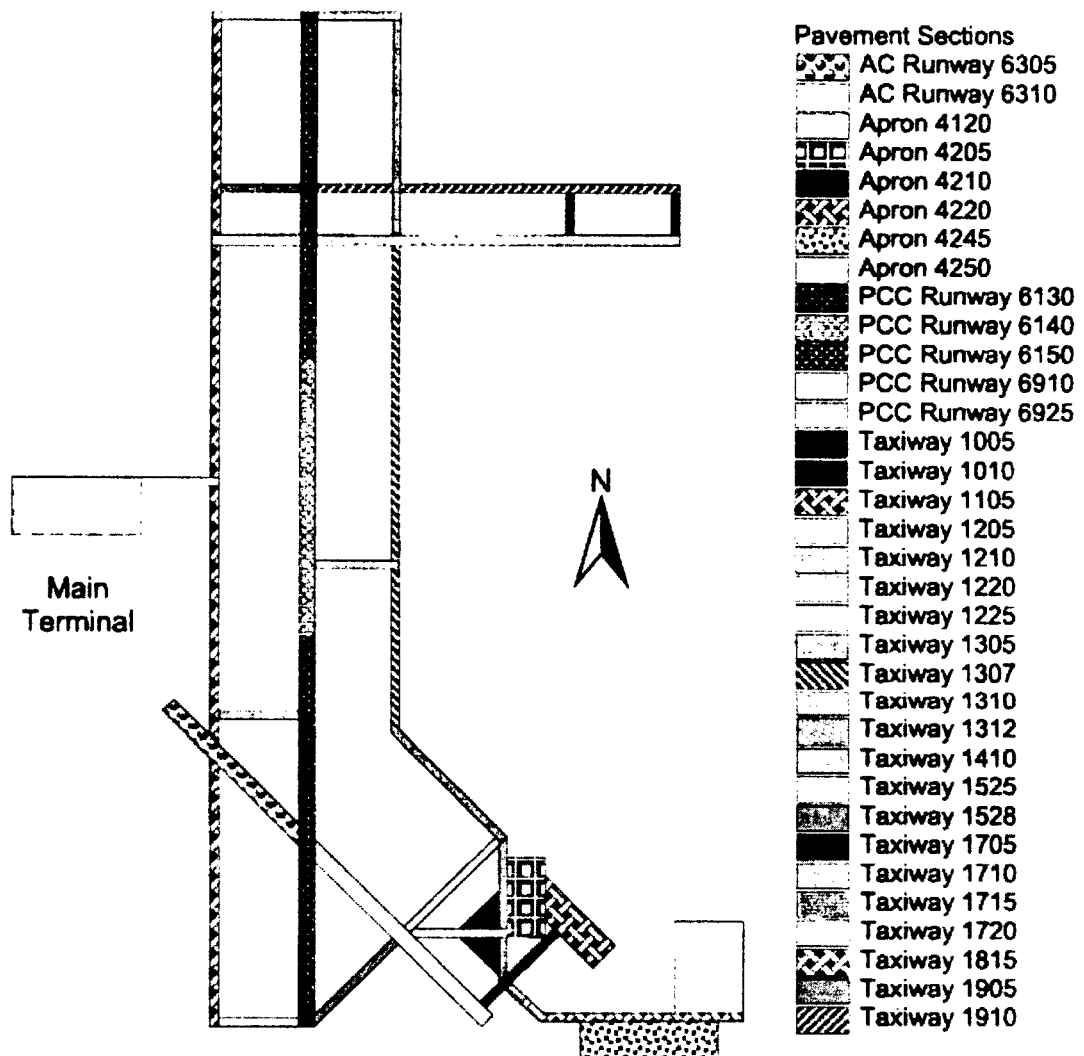


Figure 2. Hector Airport: Layout and Sections  
Source: (Ollerman and Varma, 1998)



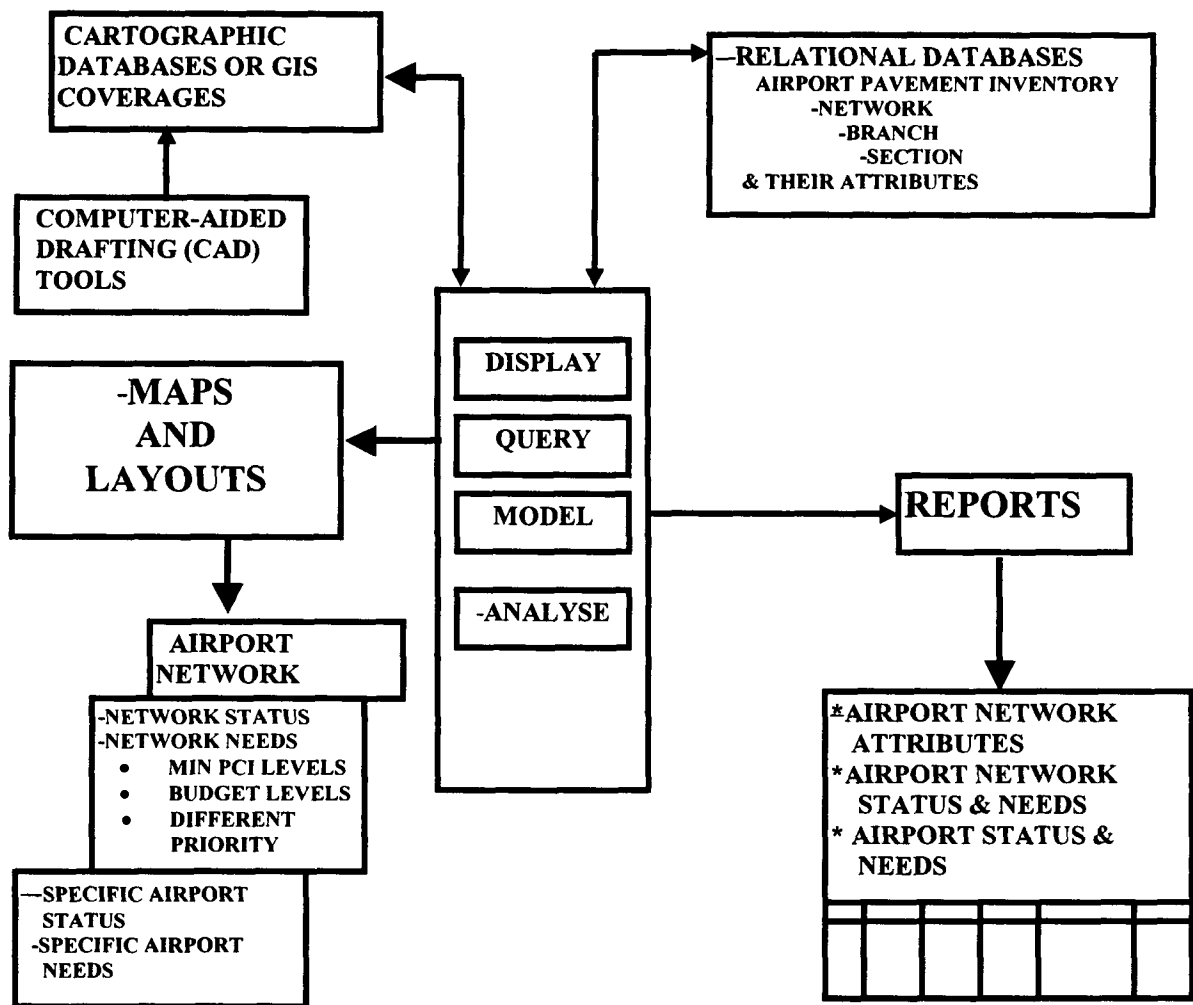


Figure 3. Generalized Architecture for GIS-based Visualization of Airport Pavement Management Information

Interactive use is for people looking for relationships between different pieces of APMI. GIS accomplishes this through query commands by allowing the user to locate sections with specific attributes or ranges of attributes. These queries can be combinations of several different attribute categories that will reflect unions or intersections of different APMI. Changes in the information presented on the map may require the user to regenerate the map from scratch when using hard copies or even CAD-based methods. GIS allows the user to create a template for a map that will query the information in the database every time the map is created, even if the data have changed between map creations.

Typically twofold process of development and visualization of APMI at a specific airport has been carried out. The process can be extended to statewide systems having multiple airports. However, the twofold process of visualization of APMI makes it difficult to use in a distributed sense for statewide systems. For statewide system, ideally the system will be set up with a central database located with the network administrator and smaller parts of the whole database located at each airport in the system. These smaller parts will only contain the information necessary for the operation of APMS at one airport. The system can be further broken down into separate computers for each of the airport departments, which will have different access and empowerment capabilities. Such capability can be possible only through seamless integration of APMS and GIS. Furthermore, numerous institutional issues need to be identified regarding hierarchy, access, and empowerment before a scale-wise integration of the APMS can be implemented.

The information pertaining to pavement sections needs to be geographically referenced to the pavement section location. Inspection information also needs to be geographically referenced to the location of the individual sample units within the pavement section. Use of GPS with GIS can facilitate this process of geo-referencing considerably. Visual inspection data will include sample identification, sample size, distresses present, distress severities, distress quantities, and the dates of all inspections. The database will also need to be able to store pictures of pavement conditions for comparison with other inspections. Inspection data from other testing will also need to be geographically referenced to the location of the testing. The collection and organization of data in this fashion will enable the airport personnel to plan and perform pavement inspections in a more consistent manner. The inspection planners will be able to determine which pavement sections have been surveyed, and this will help to determine which pavement sections need to be surveyed. This data organization will also make the task of comparing previous inspection data of sample sections with the data from current inspections a fairly straightforward task. Airport pavement personnel will want to identify questionable inspection results so they can maintain the quality of information entered in the database.

## **7. CONCLUSIONS**

Development of APMI is a complex process and there are distinctions between network and project level management functions were identified. New data collection methods, in particular non-destructive methods, have become very popular.

The importance of dividing the airport pavement into homogeneous sections for evaluation and analysis purposes is a common and necessary practice. These homogeneous sections will have the same age, construction, traffic levels, use, and relative condition.

Realizing the benefits of APMS many new airports are investing considerable money collecting and storing all infrastructure information in appropriate form and manner in a database, which can be easily accessible.

Analytically, development of deterioration curves remains a challenge for the professional community. Use of PCI as a basis has been challenged. In addition, lack of incorporation of user costs into assessments, make the assessments inaccurate or inadequate.

The need for a comprehensive database must be stressed. APMI needs to be integrated in a relational database so the different components of APMS can access and manipulate the database. In addition, there is greater need for appropriate visualization of APMI.

Such databases and visualization should cater to needs of different users of APMI. Visualization is needed to be able to effectively communicate the wide variety of information available from an APMS. The sheer quantity of information available requires the use of a data-filtering method to reduce the data to a manageable level and to highlight key information. Furthermore, there is a need to visualize the APMI within the spatial context of the airport or airport systems.

Users may wish to visualize different APMI or same APMI differently. The user may wish to see several visualizations of the unique attributes of individual pavement sections or the effects of varied budget decisions.

There is a need for seamless integration of APMS with GIS to provide dynamic linkage, fully explore the capabilities of GIS, and be able to do spatial analysis. Such integration is needed to considerably improve the responsiveness of the APMS.

Furthermore, there is a need for devising an architecture for scale-wise integration of the APMS which can eliminate data redundancies; provide access, updating, and querying capabilities; and be flexible so that different users can obtain and visualize only that APMI that is relevant to them.

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# **Electronic Reservation System Providers and the Impact of Codeshare Arrangements on Screen Display**

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## **ABSTRACT**

Airline code-share agreements in both the U.S. domestic market and international market are playing a significant role in the marketing strategies developed to win market share. Additionally, airlines are examining a wide range of electronic distribution channels in an effort to control costs and serve customers. This paper examines how codeshare agreements came into existence and the effect of codeshares on computer reservation system displays. Finally, the paper examines the results of a structured investigation of airline display patterns on leading electronic reservation system providers (ERSP) and the presence of codeshare arrangements on the screen displays consumers have to examine.

## **INTRODUCTION**

During the 1980's, in the wake of airline deregulation, code sharing developed in the U.S. between major trunk airlines and so-called "regional" or "commuter" airlines. During the 1990's, code sharing spread well beyond its early uses. The practice has proliferated between U.S. and foreign carriers serving international city-pair markets. Internationally, dozens of code share agreements now exist between U.S. airlines and their foreign counterparts covering hundreds of city pairs throughout the world (Bingaman, 1996).

Codeshare agreements take various forms (See Feldman, 1997; Rhoades and Lush, 1997; Hannegan and Mulvey, 1995). If there is a financial relationship or antitrust immunity the relationship may also be called an alliance. Early on, passengers were not parties to these agreements nor in many cases were passengers aware of the codeshare existence (Howe, 1998). The alliance trend developed as a way for most major airlines to grow globally. International mergers are prevented by national ownership restrictions, while domestic mergers have a bad name. Alliances allow the airlines to sidestep restrictive rules in nation-to-nation bilateral agreements under a system established by the 1944 Chicago Convention (Ott, 1999). "Airline



alliances come about much like any other corporate relationships where a company seeks to increase market share or reduce competition. But unlike other businesses, airlines are constrained by treaty, laws and regulations, especially in the international market place where crossborder mergers or acquisitions may not be possible. Alliances are one way around such restrictions (Howe, 1998).” Many airline partnerships, outside of the four huge airline partnerships of KLM/Northwest, Star, Sky Team and oneworld (which does not have antitrust immunity), are limited to sharing computer reservations system codes, growing out of bilateral relationships between the various nations. The participating airlines focus attention on simplified ticketing and passenger processing, linking computer reservations systems in some fashion and directing sales personnel to become ticket agents for the partner carrier (Ott, 1999).

Initially, domestic end-to-end network combinations involved code-share arrangements between major trunkline air carriers and commuter airlines that operated route networks linking the trunkline carriers' hubs with smaller cities in the region. Trunkline and commuter airlines' networks seldom overlapped to any appreciable extent, because they operated different equipment and were more efficient at serving different markets and route structures. For the most part, such a relationship still exists between U.S. major carriers and their feeder airlines.

International code-share agreements enabled both the U.S. and foreign partners to extend significantly the reach of their individual networks. By linking largely end-to-end domestic and foreign networks, the code-share partners offered "on-line" service to smaller cities located beyond its foreign partner's gateways. Such routes could not be served profitably with the individual airlines' own equipment, due to the small number of international passengers and cabotage prohibitions on foreign carriers serving local traffic.

Network expanding agreements generated two types of public interest benefits. First, network expanding code-share agreements enabled airlines to offer what many passengers consider to be the equivalent of single-line service to large numbers of passengers who otherwise would be limited to interline connections. These passengers included "double connect" passengers whose routes included U.S. cities located beyond U.S. gateway airports, and foreign cities located beyond foreign gateway airports. To the extent that passengers prefer code-share connecting services over traditional interline connecting services, the code-share agreements enabled airlines to provide valuable services that otherwise would not be available in those markets. In addition, by linking largely end-to-end route networks, international code-share

agreements can inject additional competition into city-pair markets currently served by competitors' on-line connecting flights. If neither of the code-share partners currently serves that city-pair, the new combined code-share service might be an effective competitive alternative to other carriers' existing on-line services, and constrain prices in that market (DOJ, 1998).

### **The Importance of Codesharing and Display Rules**

Codeshares can be good for airlines, expanding an airline's hub and spoke network, and therefore their market. Codeshare agreements give small carriers access to major routes and major carriers access to thinner routes and allow carriers to depict services to cities which they do not actually serve, giving the impression of a much bigger route structure than in fact is the case (Howe, 1998). "Leaving aside the question of equity, all the marketing alliances so far signed have much in common. They involve in particular the co-ordination of schedules and, where possible, the sharing of airport terminals so that the partners feed each other's services. They also are based on the sharing of computer reservations system codes to improve Computer Reservation System (CRS) display (Shaw, 1993)."

The advantage in display ranking in CRS systems provided by code-shares is important. In the early 1980's, there were two single-access systems connected to nearly 80% of US travel agencies. The systems were the SABRE system, at that time owned by American Airlines, and the APOLLO system, originally owned by United Airlines. Single-access systems provided travel agents with comprehensive booking services, showing information about airline availability, car rental, hotel and other business (Shaw, 1993). Travel agents and the CRS provided an important service to consumers by making information available about the fare and service offerings of all airlines. The CRS also offered small airlines and new entrants access to a national network for marketing services and distributing airline tickets.

Controversy over the use of the CRS soon arose. Studies indicated that travel agents would book passengers from the first screen of CRS display. A busy route, taking into account both direct flights and connecting opportunities, might require several screens to display all options in the CRS. However, analysis of bookings showed that more than 80% of bookings were being made from the first screen. Travel agents would look at subsequent screens if they were unable to satisfy the customer from the first screen. Even on the first page, position was vital. "There was a pronounced tendency for bookings to come from the top half, rather than the

bottom half of this first page, with the airline whose flight was displayed on the top line of the first page of display having a particular advantage (Shaw, 1993)."

The problem is that only a few major carriers owned a CRS. The policy of the airlines that owned the CRS was to receive a commercial advantage from the huge system investments made. Through the use of bias, the owners ensured that their flights were displayed early on the first screen, and competitor's flights were shown only on later and less accessible screens. This situation continued through the early 1980s, but led to growing concern that CRS were distorting competition by giving an unfair advantage to the airlines that owned the CRS. In November 1984, the Civil Aeronautics Board, in one of the last actions of the Board, ruled CRS displays must be unbiased, with all airlines receiving equal treatment. The CAB was abolished on 31 December 1984, under the terms of the 1978 Airline Deregulation Act.

The CAB rule making did not solve the problem it was intended to tackle. Not surprisingly, the CRS vendor airlines reacted to it with great hostility. "It amounted to a requirement that they should provide a CRS service to competitors, many of whom had spent virtually nothing on CRS development, which was equivalent to the one provided for their own services (Shaw, 1993)."

To combat assumed CRS bias by American and United through their ownership in the SABRE and APOLLO systems, in March 1991 the U.S. Transportation Department proposed rules aimed at fostering competition among airline reservation systems. The significant rules involved changes allowing for travel agents to use third party equipment and software to access airline information when making computerized bookings. At the time, airlines provided all of the equipment and software, with SABRE having a 48 percent market share and APOLLO having a 28 percent market share (McGinley, 1991). The rules were adopted in 1992, but it did not take long for the airlines to find a way around the restrictions.

In November 1996, the DOT's Aviation Enforcement Office accused American Airlines and SABRE, its affiliated computer reservations system, with violating federal rules prohibiting bias in CRS displays used by travel agents. The complaint charged that add-on software distributed by American to travel agents who subscribe to the widely-used SABRE illegally biases the displays by rearranging flights to favor American and its regional code-share partner, American Eagle. American agreed that the software, called "Preference MAAnager," rearranged SABRE flight displays to bring American and American code-share flights to the top, but only if

an agent elected to use the software. In its defense, American argued that the rules adopted on CRS bias in 1992 did not prohibit the distribution of software providing carrier-specific displays for travel agents (*Aviation Week & Space Technology*, 1996). In March 1997, a DOT administrative law judge ruled that American was not violating federal rules by offering travel agents software that lists its flights ahead of competitors in computer reservation system displays. Travel agencies whose customers frequently fly a single airline, or who receive bonuses from an airline for steering extra business its way, use preference software on personal computers to weed out competing carriers and boost sales to a favored airline (*The Wall Street Journal*, 1997). The outcome was the same either way. The difference is whether bias for a particular airline was built into a CRS or whether the travel agent "elected" to use bias in CRS displays. The court allowed for bias when the travel agent implemented the bias.

Codesharing provides one way for airlines to circumvent the CRS rules against bias. "... airlines prefer to offer connecting flights as on-line because CRS... list online flights before interline connections on CRS display screens, and travel agents tend to book customers on flights listed on the first screen (Menzies, 1999)." As preference is given to single-airline connections for display in CRS over interline connections, codesharing became increasingly attractive to the airlines. The practice of codesharing was most often used to show connection flights on two different airlines as a connection on one airline. "In displaying connecting flights as being on one airline, airlines are listing them as on-line rather than interline... they are responding to consumers' preferences for booking connecting flights on the same airline (Menzies, 1999)." When both carriers have the same two-letter code, the CRS will treat them as if connections between them are on the same carrier, whereas in fact they may be interline connections requiring a change of carriers. According to the DOT in 1986, consumers generally believe that same-carrier connections make for easier connections and are less likely to result in lost luggage (Menzies, 1999). Codesharing could provide airlines an advantage over competitors by potentially bumping flights to subsequent screens since code sharing allowed one flight to possibly be listed twice.

The CRS rules governing codesharing, also referred to as Display of Joint Operations in Carrier-Owner Computer Reservation Systems, are found in Part 256 of the Aviation Law Reports. Originally drafted in 1984, the section reads,

"The purpose of this part is to set forth a requirement for operation by air carriers of computer reservation systems used by travel agents so as to prevent unfair, predatory, and anticompetitive practices in air transportation . . . A system vendor shall not deny access to its system to two or more carriers whose flights share a single designator code, absent a determination by the Board that the use of the code constitutes a violation. A system vendor shall not discriminate against any carrier on the basis of that carrier's using the same designator code as another carrier, either by display bias, or any other means relating to providing the system...." (Aviation Law Reports, Part 256).

This set the precedent that code sharing by airlines could not be disallowed by owners of CRS systems such as SABRE.

In 1994, the DOT issued a policy statement that supported code-sharing alliances, but proposed rules that would require airlines and travel agents to notify customers, before booking flights, which airline will be operating a code-share flight and provide a written notice with the ticket naming the operating airline (Mead, 1995). Enforced only recently, Part 257.1 of the Aviation Law Reports, titled Disclosure of Code-sharing Arrangements and Long-term Wet Leases, states,

"The purpose of this part is to ensure that ticket agents doing business in the United States, air carriers, and foreign air carriers tell consumers clearly when the air transportation they are buying or considering buying involves a code-sharing arrangement or a long-term wet lease, and that they disclose to consumers the transporting carrier's identity."

Section 257.5(a) states,

"In written or electronic schedule information provided by carriers in the United States to the public, the Official Airline Guides and comparable publications, and where applicable, computer reservations systems, carriers involved in code-sharing arrangement or long-term wet leases shall ensure that each flight in scheduled passenger air transportation on which the designator code is not that of the transporting carrier is identified by an asterisk or other easily identifiable mark and that the corporate name of the transporting carrier and any other name under which that service is held out to the public is also disclosed" (Aviation Law Reports, Part 257).

Today, the airlines and travel agents are required to tell passengers when code sharing will occur. Prior to recent notification rules, passengers sold a connecting flight on two carriers were often led to believe they were traveling on a single carrier as a result of the same two-letter code being

used on both flights. Only when they arrived at the airport did they discover that one or more of the segments were flown by another airline using a small and uncomfortable turbo-prop aircraft or aboard an unfamiliar airline.

### **Past Codeshare Investigations & Rules**

As early as 1988, both the European Civil Aviation Council and the European Community announced that they would be publishing codes of conduct applicable to the operation of a CRS. These CRS codes of conduct state that on all routes, direct, non-stop flights should be listed first, followed by direct, stopping flights. Finally, connections should be shown, using the sole criterion of minimum elapsed journey time. The fastest connections should be listed first. Potentially, these codes of conduct are highly significant, because they allow for no advantage to be given to on-line compared with interline connections. As a result, theoretically, there is no benefit in European airlines signing code sharing agreements (Shaw, 1993).

Due to the growth in codeshares in April 1995, the General Accounting Office (GAO) looked at the benefits of airline alliances. When examining the practice of code sharing within the alliances, the future effects on competition were uncertain (Mead, 1995). However, GAO found codeshares using the first CRS display screen in nearly 20% of the cases it reviewed, thereby "crowding out" competing flight options to lower screens. "This situation limits competition because industry studies have shown that travel agents - who are responsible for 80% of all airline bookings - book flights that are listed on the CRS's first screen as often as 90% of the time (Mead, 1995)." While the DOT's proposed rules from the previous year sought to ensure that consumers are told which airline partner will actually operate a code-share flight, neither the regulations in place at the time nor the proposed rules limited how often the same flight could be listed in the CRS. GAO found that multiple listings of the same flight give airlines in an alliance a competitive advantage. GAO also found it important to report to Congress in 1995 that, "... the European Union in 1993 limited to two the number of times a flight can be listed (Mead, 1995)." As a result, GAO recommended that the Secretary of Transportation prohibit more than two listings of the same code-share flight in computer reservation systems. GAO had reviewed the first CRS screen for 17 international city-pairs on the Worldspan and Apollo systems and found that 19 percent of them contained three listings of

the same flight. The same flights were displayed as flights on airline "A", then airline "B", and finally a combination of the two. Because the same flight connection was listed three times and consumed six of the eight lines on the first CRS screen, a competing flight option with the same fare and elapsed flight time had been pushed to the second screen. GAO told Congress competition had been reduced (Mead, 1995).

In October 1996, GAO reported to Congress that sales and marketing strategies, when used by incumbent airlines in U.S. domestic markets, make it difficult for nonincumbents to enter markets dominated by an established airline. Examples of these strategies included travel agent commission overrides to encourage travel agencies to book travelers on one airline over another on the basis of factors other than price and CRS bias in which multiple listings of a single flight offered by an alliance partner crowd the first few screens in U.S. systems, making the booking of an alliance partner's codeshare flight more likely (Anderson, 1998).

### **Alternate Distribution Channels and Codeshares**

A July 1999 GAO report investigated the move away from traditional distribution methods. "Changes in the way the airline industry sells tickets have had mixed effects on travel agencies and consumers. Since 1995, airlines have saved as much as \$4.3 billion by reducing commissions paid to travel agencies. Through the use of new technology such as the Internet and electronic ticketing, airlines have found new ways to lower the cost of selling their tickets (GAO, 1999)." Indeed, over the past few years the expense of distribution and CRS usage had risen to the point that even airlines that owned a CRS publicly complained about the level of the fees (Klein, 1996). These fees have become major issues for the airlines, forcing them to seek alternative methods for ticket distribution.

The 1999 GAO report has ramifications for CRS rules involving code-share flights. The report says, "Changes in the travel industry allow consumers to benefit from the emergence of new ways to buy tickets. The growth in Internet sales, for example, demonstrates that some consumers prefer this way of purchasing tickets." The GAO cites a study by Jupiter Communications, a technology and consulting firm, reporting Internet sales of airline tickets had already grown to \$3 billion in 1999, or 4 percent of total sales. In another study referenced by GAO, Forrester Research found an estimated 8.2 million leisure trips were booked on-line in

1998 (GAO, 1999). 85 Million travelers booked online in 1999, representing a 146% increase since 1998 (Hall, 2000). Since the most popular Internet travel sites, also known as Electronic Reservation System Providers (ERSP), such as Travelocity and Expedia are merely web-based user-friendly interfaces for an existing CRS, issues regarding applicability of current CRS display rules when the information is regurgitated in a web-based format for consumers is an interest of concern to many parties.

## **THE STUDY**

The researchers were approached by a major U.S. airline to determine if override commissions have made their way into Internet Electronic Reservation System Providers and investigate if there were any methods currently being used to bias the customer towards specific airlines. To complete the study four types of origin and destination markets are investigated:

A flight operated between the airline hub and another city that is a hub of a different airline

A flight operated between the airline hub and another city that is NOT a hub of a different airline

A flight operated between another airline's hub and another non-hub city

A flight operated between two non-hub cities

There were a different number of O/D city pairs for each of the above criteria, due to the number of hubs (2) investigated, with a total of 10 city pairs selected for analysis.

The study design utilized a variety of shopping patterns and behaviors for investigation. There were 4 different advance purchase requirements used: 30 days, 15 days, 10 days, and 2 days. There were two different fare search methods used (where applicable), a Lowest Price (leisure traveler) search or Time Specific (business traveler) search.

There were 5 Internet travel agencies analyzed, with the five sites not operated by any airline, but instead were independent electronic reservation providers at the time of the study. The sites investigated were:

Travelocity (<http://www.travelocity.com/>)

Microsoft Expedia (<http://www.expedia.com/>)



Preview Travel (<http://www.previewtravel.com/>)

BizTravel (<http://www.biztravel.com/>)

Internet Travel Network (<http://www.itn.com>)

Lastly, to standardize data collection, research assistants collected data on Monday and Wednesday of each week. Additionally, to keep consistency between research assistants, the following guidelines were followed:

30 day advance purchase, assumed a 7 day round trip

15 day advance purchase, assumed a 5 day round trip

10 day advance purchase, assumed a 3 day round trip

2 day advance purchase, assumed a 1 day (overnight) round trip

When having to specify a time preference for departure, we used 8:00 a.m. for departure and 5:00 p.m. for return.

To conduct the research 20 students were trained into 4 person teams, one team for each ERSP, with each student specializing in a particular buying pattern. This provided the researchers a potential of 4,000 observations. Due to difficulties with on-line connections and unforeseen difficulties with one of the purchase profiles (business travel in Travelocity) the actual number of observations taken were 3,371.

## **THE RESULTS**

Overall, in particular markets the presence of codeshares are quite noticeable. Of importance is that the codeshares that appear in the itineraries investigated not only reflect the presence of the global alliances linking through particular hub cities, but also the domestic alliance arrangement between Continental and Northwest. First, we will present data on the number of codeshares appearing in the selected ERSP. At the conclusion of the results section are a series of cross tabulation tables that show codeshares by ERSP broken down by travel type (business or leisure) and by the 10 city pairs used in the research.

### *Travelocity*

Due to an unforeseen difficulty only the "9 Best Itineraries" data from Travelocity is presented. The use of this data is to represent the leisure passenger who is price sensitive. Of the possible 400 observations, only 360 are available for analysis as 4 days of observations for

the 10 day buying pattern are missing. Of the 360 observations, 145 (40.3%) had a codeshare in one of the itineraries. The number of codeshares present ranged from 1 to 8, with a mean of 3.46 codeshares present in the 145 observations reporting code shares. Table One presents the distribution of the number of codeshares present in the 9 Best Itineraries. Of note is the presence of 2 codeshares in 58 (40%) of the 145 nine best itineraries possessing codeshares.

Table One - Number of Codeshares in the  
9 Best Itineraries (n = 145)

	1	2	3	4	5	6	7	8
Number of Codeshares	3	58	28	15	19	12	8	2
Percent	2.1	40.0	19.3	10.3	13.1	8.3	5.5	1.4

In examining the cross tabulations between the city pairs and the codeshare variables Table II in the Appendix, codeshares do not become an issue with the leisure itineraries until those city pairs representing routes across the middle of the country. The cross tabulations show the city pairs of STL-IAH, STL-SEA, MSP-MSY and RNO-RDU as having the most codeshares in the itineraries, with the city pairs of STL-IAH and RNO-RDU reporting the highest frequency of codeshares within the observations. Examining the output from the Travelocity web site, the majority of the codeshares listed in the 9 best itineraries are codeshares between Continental and Northwest. Utilizing the combinations possible due to hubs in Houston, Memphis, Detroit and Minneapolis, these airlines dominate the frequency of options displayed for the city pairs of STL-IAH and RNO-RDU.

### *Expedia*

For Expedia there is a total of 688 observations available. For the business travel pattern 300 observations are available as there was a difficulty with the 2 day buying behavior pattern and this was dropped. For leisure travel, 388 of a possible 400 observations are present.

Business: To select an itinerary as a business traveler a user must first examine a list of departure flights and then select one before seeing a list of return flights to select from. In the departure listing 231 (77%) of the 300 observations had codeshares present. In the return listing 214 (71.3%) of the observations had codeshares listed. The tables below present the number of codeshares present in these two listings.

Table Two – Number of Codeshares displayed in Departure Flights

	1	2	3	4	5	6	7
Frequency	118	50	5	19	15	17	7
Percent	39.3	16.7	1.7	6.3	5.0	5.7	2.3

Table Three – Number of Codeshares displayed in Return Flights

	1	2	3	4	5	6	7
Frequency	67	53	53	11	3	14	13
Percent	22.3	17.7	17.7	3.7	1.0	4.7	4.3

In examining the Appendix (Table IV) for the business travelers the city pairs of JFK-LAX, STL-ATL, and RNO-RDU have codeshares in 100% of the observations. For the JFK-LAX and STL-ATL city pairs the presence of international alliance codeshare partners help to drive the number of codeshares. For the RNO-RDU city pair the presence of the Northwest / Continental alliance drives the number of codeshares.

Leisure: For the leisure passenger Expedia also displays a number of itineraries under the search for the “Best Fares” although the number of itineraries displayed is not nine as in Travelocity. In examining the 400 observations, 138 (34.5%) of the observations had codeshares present. The majority of the observations had only one codeshare in the listing, as shown in Table Four.

Table Four - Number of Codeshares displayed in Best Fares  
n = 400

	1	2	3	4
Frequency	86	40	9	3
Percent of total observations	21.5	10	2.3	.8

In examining the Expedia leisure cross tabulations in the Appendix (Table VIII), the greatest number of codeshares are in 4 city pairs, STL-IAH, STL-SEA, MCI-MSY, and RNO-RDU. For the STL-IAH the Delta, Swissair and Sabena alliance which was in operation at the time of data collection drives the number of codeshares. For the other three city pairs the Northwest / Continental alliance drives the number of codeshares.

### *Preview*

For Preview, which had not been purchased by Travelocity at the time of data collection, there was a total of 778 valid observations out of a possible 800. For the business purchasing

behavior there were 399 observations and for the leisure purchasing pattern 379 valid observations.

Business: Much like the other sites, Preview presents a list of departing and return flights for the traveler to select from. For the outbound listing there were 219 (54.8%) codeshares in the 399 observations, while for the return listing there were 194 (48.6%) codeshares in the 399 observations. The tables below present the frequency of codeshares appearing. In examining the cross tabulation tables for Preview in the Appendix (Table IX and Table X), we see the majority of these code shares appear in the city pair impacted by the domestic codeshare of Northwest and Continental.

Table Five - Number of Codeshares displayed in Outbound Listing  
n = 399

	1	2	3	4
Frequency	173	38	6	2
Percent of total observations	43.3	9.5	1.5	.5

Table Six - Number of Codeshares displayed in Return Listing  
n = 399

	1	2	3	4
Frequency	67	74	51	2
Percent of total observations	16.8	18.5	12.8	.5

Leisure: For the leisure purchasing pattern 116 (30.6%) of the 379 observations have codeshares. This number is somewhat possibly reduced due to the fact that Preview only displayed domestic flights. Therefore, all the codeshares present are from domestic arrangements, and do not show the influence of any international alliances. This can be seen examining Table XI in the Appendix. The frequency of codeshares is for leisure purchasing behavior is shown below in Table Seven.

Table Seven - Number of Codeshares displayed in Leisure Itineraries  
n = 379

	1	2	3	4
Frequency	47	34	21	14
Percent of total observations	12.4	8.9	5.5	3.7

### *Internet Travel Network*

The ITN site is interesting for the manner in which the same format is used for both buying behaviors. Unlike Travelocity and Expedia, which have different designs for the type of travel one is arranging, a user must enter into a personal profile page to adjust the search parameters guiding the selection process. The profile allows a user to set the parameters for the flight search by using a list of factors from price, to departure times, to fewest connections. All of the requested number of flight options appear on one page the user scrolls down. After selecting the flight options, users must click through to see the price of the itinerary selected and any lower priced options the site has found. For this project, the researchers utilized the 15 available flight options. The students were required to enter the personal profile option and using the "sort air choices by" button select the "price (lowest to highest)" for leisure buying behavior, and "time (closest to inquiry)" for business buying behavior. For the project students only collected observations from the "Flight Availability Selections" page and did not click through to price the itinerary. Due to unforeseen difficulties, two days of observations were not collected, leaving 380 observations for each of the buying behavior profiles.

Business: Further investigation lead to the dropping of 7 observations from the business profile, leaving 373 valid observations for the business purchasing profile. The researchers investigated the presence of codeshares in the departures and return flight listing. In the departures listing 242 (64.9%) of the 373 departure observations reported the presence of a codeshare flight. For the 242 observations displaying a codeshare, a mean of 2.5 codeshares per departure listing is found.

Table Eight – Number of Codeshares displayed in Departures Listing  
n = 242

	1	2	3	4	5	6	7	10
Frequency	100	67	5	23	29	10	7	1
Percent	41.3	27.7	2.1	9.5	12.0	4.1	2.9	.4

In examining the cross tabulation tables for business departures in the Appendix (Table XIII) codeshares do not appear in only one city pair, JFK-MSY. The largest number of codeshares are on the city pairs of JFK-LAX and JFK-MCO. These appear due to the competing international alliances on the JFK-LAX route (Star Alliance and oneworld) and the presence of the now defunct Delta, Swiss Air and Sabena alliance on the JFK-MCO route.

For the return listing, 263 (70.5%) of the 373 observations reported the presence of a codeshare. For the 263 observations, a mean of 2 codeshares per return listing is found. Table Nine displays the frequency.

Table Nine – Number of Codeshares displayed in Return Listing  
n = 263

	1	2	3	4	5	6
Frequency	69	151	30	4	1	8
Percent	26.2	57.4	11.4	1.5	.4	3.0

In examining the cross tabulation table for returns in the Appendix (Table XV) codeshares are well represented in all the city pairs except JFK-MSY and SAN-BDL. The widest distribution of code shares is found in the JFK-MSY and JFK-LAX city pair. Again, the presence of the international alliance codeshares dominates these city pairs.

Leisure: Unlike the other sites, leisure travel purchasing requires a change in profile, not another display option like some of the other ERSPs investigated. So, one does not get a complete itinerary, but instead a departure and return listing of flights to select from. For the departure listing 250 (65.8%) of the 380 departures report the presence of a codeshare, with a mean of 2.34 codeshares in the departure listing. Table Ten displays the frequency of codeshares in the departure listings.

Table Ten – Number of Codeshares displayed in Departures Listing  
n = 250

	1	2	3	4	5	6
Frequency	117	56	5	27	36	9
Percent	46.8	22.4	2.0	10.8	14.4	3.6

In examining the return listings 281 (73.9%) of the 380 return flight listings had a codeshare present with a mean of 2.48 codeshares per departure listing. Table Eleven displays the frequency of the codeshares in the return flight listings.

Table Eleven – Number of Codeshares displayed in Return Listing  
n = 281

	1	2	3	4	5	6	7
Frequency	91	92	46	14	4	29	5
Percent	32.4	32.7	16.4	5.0	1.4	10.3	1.8

In examining the cross tabulation tables in the Appendix (Table XVII and Table XIX) for the leisure purchasing behavior the same pattern of codeshare activity is present as the business purchasing behavior. The city pairs JFK-LAX and JFK-MCO display the highest frequency of codeshare activity, while the city pairs JFK-MSY and SAN-BDL have almost no codeshares. For users of ITN the international alliances and the impact the alliances can have on screen display are clearly present.

### *BizTravel*

Of the ERSPs investigated during the time period of the research, BizTravel was the only one owned by a traditional travel management company, Rosenbluth International. As such, BizTravel as an ERSP is targeted for the business traveler and the variety of loyalty plans (airline frequent flyer plan, rental car, hotel, etc..) the traveler may belong to. Unlike the other systems that provide a long list of flights, BizTravel first presented three complete itineraries for review and then additional lists of outbound and return flights are presented for review. For leisure travel the "Flight Preference" option was set to lowest price and for the business travel purchasing the Flight Preference" was set to display by desired schedule. There were 396 valid observations for both purchasing behaviors utilized.

Business: In the three recommended itineraries, 127 (32.1%) of the 396 observations possessed a codeshare as part of a recommended itinerary. If one continued and examined the number of codeshares in the additional available flights outbound 245 (61.6%) of the observations in the outbound listings had a code share present. In the additional return flight listings 257 (64.8%) of the return listings had a codeshare listing. The tables below show the frequency of the codeshares in the optional outbound and return flight listings.

Table Twelve – Number of Codeshares displayed in Outbound Listing  
n = 245

	1	2	3	4	5	6
Frequency	11	51	82	98	2	1
Percent	4.5	20.8	33.5	40	.8	.4

Table Thirteen – Number of Codeshares displayed in Returns Listing  
n = 257

	1	2	3	4	5	6
Frequency	9	13	101	102	31	1
Percent	3.5	5.1	39.3	39.7	12.1	.4

Leisure: In the recommended three itineraries only 60 (15.1%) codeshares are present in the 396 observations. In examining Table XXIV in the Appendix, the majority of the codeshares in the recommended itineraries (35 of the 60) appear in the RNO-RDU city pair.

For the outbound option flight listing there are 251 (63.4%) codeshares in the 396 observations. For the return listing there are 256 (64.6%) codeshares in the 396 observations. The tables below present the frequency of codeshares in the additional flight listings.

Table Fourteen – Number of Codeshares displayed in Outbound Listing  
n = 251

	1	2	3	4	5
Frequency	20	54	82	94	1
Percent	7.9	21.5	32.7	37.5	.4

Table Fifteen – Number of Codeshares displayed in Return Listing  
n = 256

	1	2	3	4	5
Frequency	8	13	90	111	34
Percent	3.1	5.1	35.1	43.4	13.3

Examining the tables (Table XXVI and Table XXVIII) in the Appendix that 7 of the 10 city pairs investigated show a high degree of code share activity in the listings. Those city pairs not showing code share activity are JFK-MSY, STL-IAH and SAN-BDL. Looking at the city pairs displaying a high degree of international code share activity in the JFK-LAX and JFK-MCO city pair listings and a high degree of the domestic Northwest / Continental code share activity on the STL-ATL and MSP-MSY city pairs.



## CONCLUSION

Except for Preview Travel, the ERSs investigated all displayed a high level of codeshare activity in the displays shown to potential travelers. The code share activity that is shown during the time period under investigation is of two origins. On routes utilizing a city with a large international presence, especially JFK, the international alliances and the codeshare opportunities that come from the alliances do appear on the display. Again, Preview was the only site this did not occur because Preview did not book international travel. On some of the north/south routes, especially those in the middle of the country, the Northwest/Continental alliance made its presence felt. Having the opportunity to utilize routings through 4 hub cities in the middle of the country: Detroit, Minneapolis, Memphis, Houston; and especially with the city pairs investigated where one of these cities was either the origin and destination city, the different routings available by using the other hubs dominates some of the itineraries displayed in the observations. Clearly, the power of an alliance and the benefit of the codesharing opportunities that come about are supported in this investigation.

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**Table I: Are Codeshares present in the 9 Best Itineraries by O&D city pair?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes			1	2	29	29	29	20	35	
No	36	36	35	34	7	7	6	17	1	36

**Table II: Number of Codeshares in the 9 Best Itineraries options by O&D city pair**

[illegible]



## Business

### Table III: Are Codeshares found in the Departure listings?

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes	30	29	1	30	29	29	28	25	30	
No		1	29		1	1	2	5		30

**Table IV: Number of Codeshares present in the Departure listing by O&D city pair**

[illegible]



### Table V: Are Codeshares found in the Return Listings?

Table VI: Number of Codeshares present in the Return listings by O&D city pair[illegible]



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## Leisure

Table VII: Are Codeshare listed in Flights Presented?

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes	4		1	1	30	22	9	22	32	17
No	35	39	38	37	9	17	30	17	6	22

Table VIII: Number of Codeshares present in the departure listings by O&D city pair

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1	4			1	24	5	6	16	21	9
2			1		5	15	2	3	10	4
3					1	2		3	1	2
4							1			2



## Business

Table IX – Number of Outbound Codeshares for Each City Pair

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1		1	6		40	33	2	38	33	20
2						1	30		7	
3							6			
4							2			

Table X – Number of Return Codeshares for Each City Pair

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1				18	36				1	12
2					1	26	20	6	21	
3						4	19	11	17	
4			1						1	

## Leisure

Table XI – Number of Codeshares for Each City Pair

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1					6	1	8	8	19	5
2					5		4	13	12	
3					8		4	7	2	
4					7		2	5		





## XII: Are Codeshares found in the Departure listings?

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
<b>Yes</b>	38	38		37	15	27	37	13	35	2
<b>No</b>			38		22	10		24	2	35

**Table XIII: Number of Codeshares present in the Departure listing by O&D city pair**

[illegible]



## Business

**Table XIV: Are Codeshares found in the Return Listing?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
YES	38	38		36	34	28	36	16	35	2
NO			38	1	3	9	1	21	2	35

**Table XV: Number of Codeshares present in Return listing by O&D city pair**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1		24		5	32	2	1		4	1
2	15	2		31	2	26	33	13	28	1
3	20	2					2	3	3	
4		4								
5		1								
6	3	5								



## Leisure

**Table XVI: Are Codeshares found in the Departure listings by O&D city pair?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes	38	38		37	23	2	37	38	36	1
No			38	1	15	36	1		2	37

**Table XVII: Number of Codeshares present in the departure listings by O&D city pair**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1				6	22	2	12	38	36	1
2				31	1		24			
3		4					1			
4	3	24								
5	31	5								
6	4	5								



## Leisure

### Table XVIII: Are Codeshares found in the Return listings by O&D city pairs?

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
<b>Yes</b>	38	38		37	32	37	38	22	37	2
<b>No</b>			38	1	6	1		16	1	36

**Table XIX: Number of Codeshares present in the Return listings by O&D city pairs**

[illegible]



## Business

**Table XX – Are Codeshares present in the Recommended Combinations?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes		1	1		1	40	38	11	35	
No	40	39	39	40	39		1	28	3	40

**Table XXI – Are Codeshares present in the Outbound available flights?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes	40	40	3	40	1	40	38	5	37	1
No			37		39		1	34	1	39

**Table XXII – Are Codeshares present in the Return available flights?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes	40	40	2	40	6	39	35	15	37	3
No			38		34	1	4	24	1	37



### Table XXIII – Are Codeshares present in the Recommended Combinations?

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
<b>Yes</b>					2	3	8	10	35	2
<b>No</b>	40	39	39	39	38	37	32	29	5	38

### Table XXIV - Number of Codeshares in the Recommended Itineraries

[illegible]



## Leisure

**Table XXV – Are Codeshares present in the Outbound available flights?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
YES	40	38	2	39	2	40	40	10	40	
NO		1	37		38			29		40

**Table XXVI – Number of Codeshares shown in the Outbound available flights**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1		1			1		8	9	1	
2	17	1	2	1			27	1	5	
3	23	20			1	1	3		34	
4		16		37		39	2			
5				1						



## Leisure

**Table XXVII - Are Codeshares present in the Return available flights?**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
Yes	40	39		39	5	40	38	14	40	1
No			39		35		2	25		39

**Table XXVIII - Number of Codeshares shown in Return available flights**

	JFK LAX	JFK MCO	JFK MSY	STL ATL	STL IAH	STL SEA	MSP MSY	MCI MSY	RNO RDU	SAN BDL
1					1			6		1
2	3						6	3	1	
3	19	23		1	3	11	21	5	7	
4	18	16		8	1	27	10		31	
5				30		2	1		1	



# **Strategic classification of current airline alliances and examination of critical factors involving the formations-an explorative perspective**

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## ***Abstract***

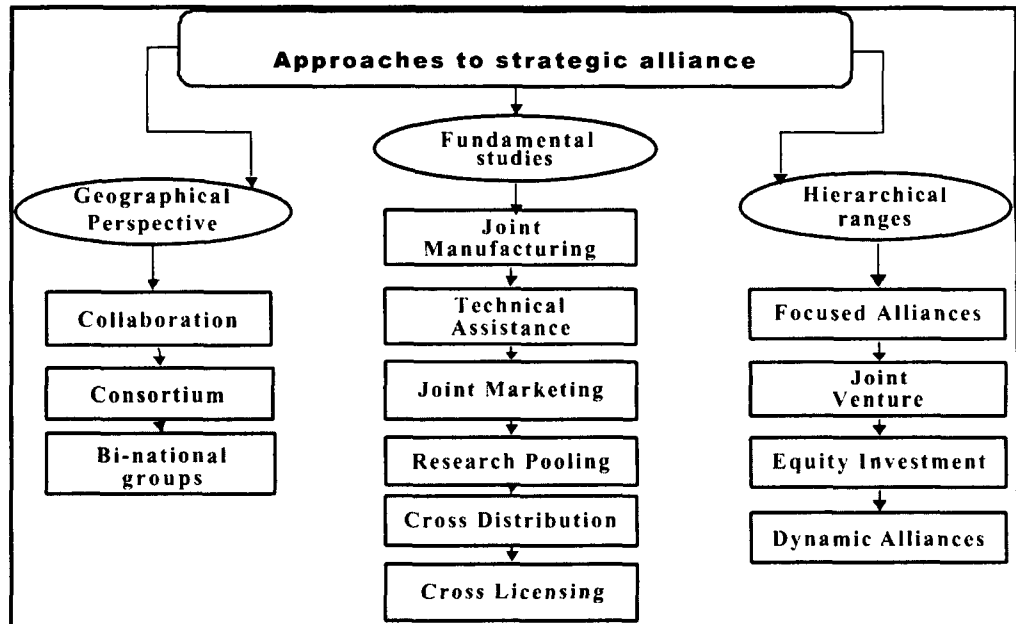
This research identifies several categories of airline alliances through a strategic classification of various alliance activities involving the major airlines for the period 1989 to 1999. Such a classification enables this research to examine how strategic alliances are developing in the markets of North America, the European Union and the Asia Pacific regions, and what are the critical factors involved with a formation and development of alliances. Findings support the argument that the liberalization process, being different between countries, can affect airlines of these countries entering different types of airline alliances. This exploratory study facilitates research undertaken by the researchers to further examine effects and consequences of different types of the airline alliances.

## ***Background to the research***

In the 20th century, companies have experienced changes in a diverse environment, including the shake up of the social structure, economic progress and technological advances (Limerick and Cunningham, 1993). The social structural evolution resulted in dismantled hierarchical cultures within industries. The economic changes resulted in a change of lifestyle patterns and increased consumption (Goeldner, 1992). The technological changes have lifted the industrial society into an information society (Limerick and Cunningham, 1993). The progress of information technology has not just enabled banking between countries, but also allowing communication, research and development, and business coordination through the communication network. These social, economic and technological changes are paving a way for organizational globalization. Facing this changing environment, most industries have adopted various management strategies, including cooperative strategies, to cope with the changing environment challenges. Strategic alliances haven been employed as one of the forms of cooperative strategies.

Previous studies on strategic alliances can be viewed from several perspectives, including geographical scope (Byttebier and Verroken, 1995; Dussauge, 1990; Farrar et al., 1991), fundamental alliances (Pucik, 1988; Kanter, 1989), and hierarchical ranges (Faulkner, 1995; Pucik's, 1988; Robinson and Clarke-Hill, 1994 & 1995). These concepts are shown in Figure 1. and briefly discussed next.

Figure 1. Summary of approaches to strategic alliances in the current literature



The geographical perspective studies strategic alliances in terms of collaboration, consortia, and bi-national groups. The fundamental studies review strategic alliances in terms of joint ventures, technology change, licensing, cross-distribution, and co-production. In turn, hierarchical ranges emphasize the levels of cooperation in an alliance such as simple coordination or complex alliances in terms of nature and features. The simpler forms of alliances can be reviewed as focused alliances such as research and development (R&D) or sharing resources. The more complex forms may include equity investment, and various activities of coordination, from joint manufacturing to cross licensing, and to cross distribution of products.

Enterprises pursue alliances for the purposes of being able to cultivate multinational markets, save time in learning curves, share resources and manage risks, gain global brand reputations, and economies of scale and scope. Previous studies, although some

of them are overlapping in concepts or terminology, show various approaches to strategic alliances. Similar to enterprises in general, the airline industry has also adopted strategic alliances.

Since 1994, there have been a rapidly increasing number of airlines entering strategic alliances. Meanwhile the airline industry has experienced several growth periods (Wang, et. al, 1999), despite the two economic depressions due to the Gulf War during 1990, and the Asian financial crisis in 1997. It is not just the numbers of alliances that has increased in the last decade; there are also various formations emerging. What follows is consideration of what are the alliance strategies developed in the airline industry? What is the impact of the strategic alliances on airline performance?

### ***Research problems***

While airlines are increasing the number of alliances and the levels of involvement to the alliances, there are also some problems identified. One of the problems is seen as there are only a few empirical investigations about the effects of strategic alliances. Given this gap, there is even fewer studies have examined the effects of various strategic alliances mergers in the air transport markets. Secondly, the stages of market liberalization between North America, the European Union (EU) and the Asia Pacific region (AP) differ (Eleck, Findlay, Hooper and Warren; 1999; PC, 1998, Oum, 1998). This situation may have affected the progress of the airlines entering strategic alliances. Thirdly, as airlines exercise different tactics on different routes, the various formations may therefore have different effects on airline performance and market competition. In fact, it has been argued that the US has been perusing 'open skies' while most of the markets in the AP region are still regulated and only a few AP airlines have been invited to enter the 'open skies' (Eleck, et.al, 1999; Hooper and Findlay, 1998; PC, 1998). As the airlines of North America are gaining more access to the AP markets through beyond rights, the economic effects of 'open skies' on the AP markets are questioned. Thus, there is a need to study these issues. However, the current studies of strategic alliances, particularly airline strategic alliances show there is a lack of clear definitions of the current alliance activities, which may partly result from the complex features and changing tactics of airline alliances. These problems

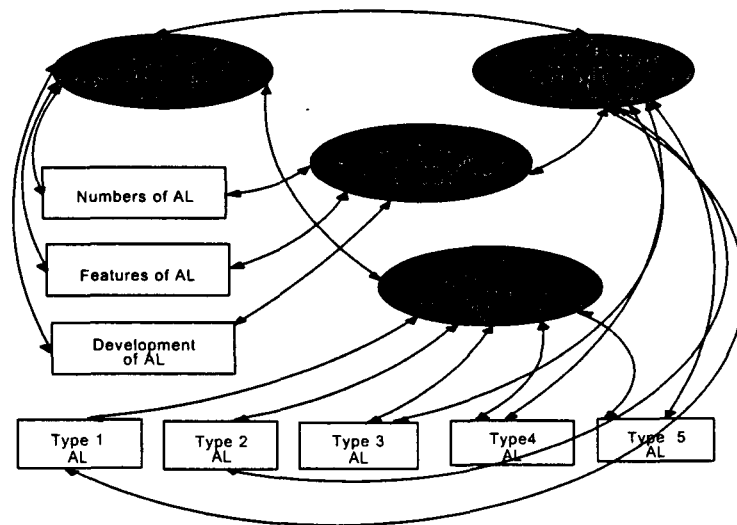
have motivated the researchers to conduct this research. Being directed to this goal, this research is designed and the research issues are specified as:

**RI 1:** *What are the patterns of the development of airline strategic alliances in the markets?*

**RI 2:** *What are the critical factors involving a formation and development of airline strategic alliances?*

Aiming at addressing these issues, this paper firstly develops a conceptual model, and this model is presented in figure 2. This model shows approaches to the research issues and the presumed interrelationships between the factors to be examined. The conceptual model suggests the manner, in which the number and features of alliances increase are related to the liberalization process. The liberalization process implies the liberalization stages of North America, the EU, and the AP regions.

Figure 2 Conceptual model of the research: development of airline alliances



Source: developed for this research

### ***Theoretical study of the strategic classification***

Airline alliances vary in features and areas of cooperation. Thus, it is necessary to classify the alliance activities before examining the effects of different types of

alliance. This research therefore first of all conducts a strategic classification of the alliance activities currently undertaken by international carriers. Results of the classifications are shown in this section.

### **New bilateral services**

Currently Bilateral Air Service Agreements are based on the principle of reciprocity, an equal and fair exchange of rights between countries. Although they vary in form, they generally specify services and routes to be operated between the two countries, designate airlines and the capacity to be provided by each airline (Oum and Yu, 1997; Rimmer, 1997). The new bilateral route specific services observed by this study mainly include the service agreements based on bilateral traffic rights between countries. The agreements offer carriers access of entry, and hence enable carriers operating flight services across country borders on a basis that the rights permit. The new bilateral services also include the services that apply beyond rights. For example, Air Canada launched a weekly Toronto-Berlin/Schonefeld route, using fifth-freedom rights from Paris. Details of this classification is shown in the framework presented in Appendix 1.

### **Code sharing**

Code sharing provides cooperation between carriers other than just access for city-pairs or non-stop flights. Under a code sharing agreement, one partner (the code sharing partner) assigns its airline designator a code to the flight of its partner the operating carrier (ICAO, 1997). Typically code sharing is accompanied by a suite of other coordinated services designed to provide passengers with smooth connections between flights operated by the partner carriers (ICAO, 1997). Code share could hence share a part of the nature of joint activities, if the cooperation is no longer limited within exchanging designation code or buying a block of seats, but involving cooperation of ground services. In that case, code share is classified into the category of joint activities, due to its being multiple cooperation in nature. The definitions of code share are specified in the framework in Appendix 1.

### **Joint activities**

The current literature shows that various airline alliances are mixed together under equity or joint operations. This study sets up a framework for defining areas of joint

activities. It firstly, separates code share and block space sales from the 'joint activities' and considers them as the type two –code share alliance. It also shifts FFP and joint marketing up into the category of marketing alliance. Further, it specifies joint activities within the areas of coordination of ground handling, joint use of ground facilities, coordination of flight schedules, joint maintenance and purchase of aircraft/fuel. A parallel alliance is considered by this research as either simply a code share or a joint activity. In that later case, it ought to be multiple cooperation in nature. A complementary alliance is regarded as a joint activity, if it is multiple cooperation within the areas of joint programs (see Appendix 1).

### **Marketing alliances**

The marketing alliances examined in this research include the global alliances, such as Star Alliance, oneworld, or Global Wings. Some international airlines that have entered regional alliances with agreements covering the same areas of cooperation are also categorized into the group of marketing alliances. According to GAO (1995), global alliances often involve high integration and coordination of flights, scheduling, advertising and frequent flier programs. Regarding the item of coordination of flights, marketing alliances partly overlap with joint activities. However, marketing alliances aim at attracting passenger market and creating customer satisfaction through various cooperative operations. Thus, alliances in the category of marketing alliances have the major characteristics of cooperation in the marketing field. Definitions for marketing alliances are specified in the framework in Appendix 1.

### **'Open skies'**

'Open skies' negotiations were tabled by countries in Northern America and European Union in 1992. The 'open skies' policy (see Appendix 1) shows that 'open skies' agreements are broad commercial alliances. The characteristics of the 'open skies' are also shown by the memorandum of understanding signed between the countries. The memorandum of understanding normally includes code share agreement on international and domestic flights, reciprocal FFP, lounge access, through check-in, integration of boarding procedures, computer reservation system linkage, joint marketing and sales programs. An example is the alliance between Northwest/KLM, through an agreement signed in 1992 (Airline Business, 1992). From 1993, Northwest and KLM tied up their commercial ties, which enabled the two

airlines to schedule common flights, cooperate in pricing and sales, and even share revenue (IC, 1997). The specified definitions for 'open skies' are presented in Appendix 1 and 2. Following this study another theoretical study is conducted, which is discussed next.

### ***Theoretical study of market conditions***

It is pivotal to identify the critical factors involved with the formation of alliances, and hence to explain why carriers engage in different types of alliances. Previous studies regard antecedent as an important factor for a company to enter an alliance, as specific and environmental factors influence the propensity of the company to enter an alliance (Glaister, 1996; Varadarajan and Cunningham, 1995; Vyas et. al. 1995). A company choosing a partner also depends on strategic convergence and divergence, such as a larger market and central location, or a small market but central location, or a small market and peripheral location (Staniland, 1997). These previous studies take a general perspective of alliance objectives and market nature as important factors for forming alliances.

This paper considers more specific factors and provides a detailed examination of the development of strategic alliances, particularly the dynamic features of alliances. This is partly because in the air transport markets all commercial aspects of international air transport matters have been generally governed by bilateral air treaties between the countries involved (GAO, 1995, IC, 1997, PC, 1998, Oum, et. al., 2000). Air Service Rights were a complex global network of bilateral air services agreements, to guarantee the scheduled and non-scheduled (charter) airlines certain traffic 'freedoms' (PC, 1998). International air transport is both "location-constrained" and "nationality-constrained" (Staniland, 1997) These constraints restrict which airlines may offer international services from their airports and to and from what points abroad airlines may offer international services. As strategic alliances in the air transport market are restricted by Air Service Agreements (ASA), the governance of ASAs will affect the development of alliances.

Also, it is argued that liberalization of this kind of service trade hinges not on the process of trading itself, but rather on the conditions under which providers of services are permitted to establish an actual direct or indirect presence in a specific

national market (Staniland, 1997). Currently Asian airlines have been generally slow and entered fewer alliances with each other or other airlines (Hooper, 1997). Most Asian countries are not prepared for 'open skies', and governments still maintain restrictions in free trading policy (IC, 1997; Hooper, 1997; Oum, 1998; PC, 1998; PC, 1999).

The progress of airline alliances may be explained as due to air transport market structures differing from region to region. For example, in 1979, the U.S. domestic air transport markets were deregulated (IATCA, 1979). In March 1992, the United States offered to negotiate trans-border "open skies" agreements with all European countries. Hence, the first US "open skies" deal was signed in September 1992 between the U.S. and the Netherlands, and then Canada in 1995 (Airline Business, 1992, 1995). In 1995, the US Department of Transportation (DOT) established its strategy for pursuing more liberal 'open skies' arrangements (DOT1995). During the 1990s, The European airline industry was liberalized through the implementation of three phases, and these were completely finished in 1997 (Graham, 1997). The US market deregulation and liberalization in Europe have provided necessary and important conditions for the significant progress of airline strategic alliances. When North America air traffic was fully liberalized in April 1997, the airline industry in the Far East was strictly regulated (Hooper, 1997; Oum, 1998). When the US extended an invitation to enter into open aviation agreements to a number of countries in 1995, airlines in the Asia- Pacific region were still slow to form alliances (IC, 1997; Hooper, 1997; Oum, 1998; PC, 1998; PC, 1999). Based on these studies some methods are developed for the statistical analyses. These methods are discussed next.

### **Methods**

Based on the theoretical studies, some quantitative methods are employed for conducting a statistical analysis. The sample used for the observation of airline alliances included 27 major international airlines (see Table 1).

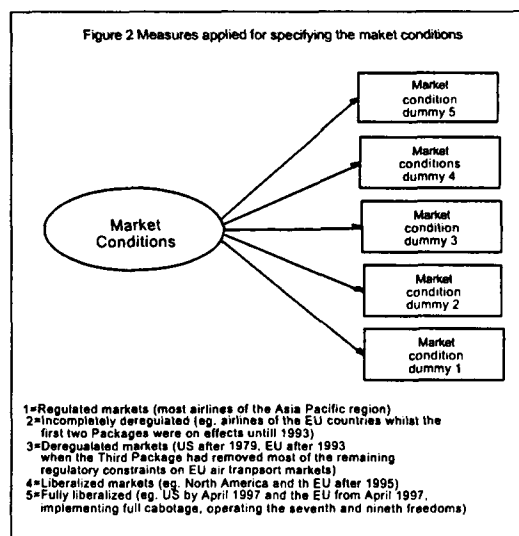
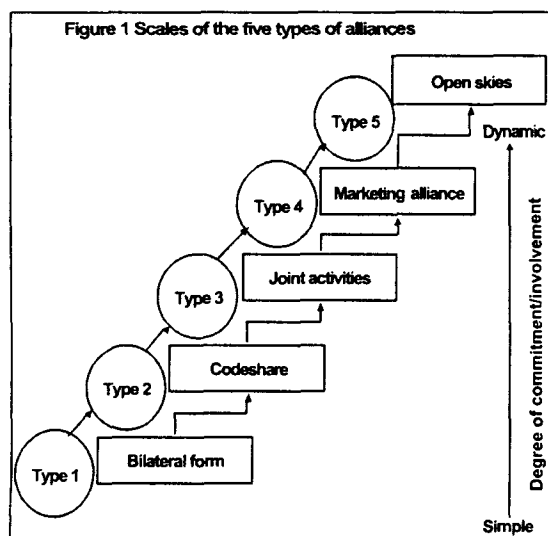
Based on the critical review of the market conditions of the three markets, some measures are formed for measuring the market conditions. These measures are considered as five categories in general: 1) regulation, 2) in the process of



deregulation, 3) deregulated, 4) in the process of liberalization, and 5) fully liberalized (see Figure 2). These measures are employed in conjunction with the development of different types of strategic alliance (see figure 1), to examine how different alliances developed at each market, and whether the developments are related to market conditions. Some statistical tools are employed in testing the assumptions. Towards studying the assumptions, some hypotheses and structural equations are developed and presented below.

Table 1 The 27 major international airlines used as subjects for this exploratory study

North America Airlines	Design Code	European Airlines	Design Code	Asian Airlines	Design Code
Air Canada	AC	Air France	AF	Air India	AI
American	AA	Alitalia	AZ	Air NZ	NZ
Continental	CO	British Airways	BA	All Nippons	NH
Delta Airlines	DL	KLM	KL	Cathay Pacific	CX
Northwest	NW	Lufthansa	LH	Air China	CA
SAS	SK	Swissair	SR	Japan Airlines	JL
United	UA	Virgin Atlantic	VIR	Korean	KE
Canadian	CDN			Malaysia Airlines	MH
USAir	AL			Qantas Airways	QF
				Singapore	SQ
				Thai Airways	TG



### **Hypothesis and structural models**

Hypotheses and structural models developed for the empirical investigation are as follows:

**Hypothesis 1:** *There is a significant difference between the development of strategic alliances of the three markets*

**Hypothesis 2:** *There is a significant difference between the development of airline strategic alliances with the different market conditions*

**Hypothesis 3:** *Airlines in markets liberalized involve more alliances than the airlines in markets regulated.*

**Hypothesis 4:** *There is a linear relationship between the development of airline strategic alliances and increase of market abilities*

**Hypothesis 5:** *Liberal markets lead to the more numbers and integrative alliances formed in the markets.*

Hypothesis 1 tests the difference between the development of airline alliances in the three markets. The equation model structured for testing this hypothesis is expressed as:

$$\sum A_i \neq \sum A_k \quad A_i = \{al\}_i, i=1, 2, 3, i \neq k \dots\dots\dots (4.1)$$

Where  $\sum (A)$  refers to the total alliances and  $i$  is a market, and  $k$  refers to a comparative market.

Hypothesis 1 also tests the differences between the five types of alliances formed by the airlines in the three markets. The equation 4.1 therefore is denoted as:

$$\sum_{j=1}^5 (al)_{ij} \neq \sum_{j=1}^5 (al)_{kj} \dots\dots\dots (4.2)$$

Where  $j$  is a vector of a set of alliance variables, and  $\sum_{j=1}^5$  refers to the sum total of the alliances, including the sum total alliances of type one to type five.

The equation model (4.1) is further specified as:

$$\sum_{j=1}^5 al_{ij} \neq \sum_{j=1}^5 al_{kj} \dots\dots\dots (4.3)$$

Where  $\sum_{j=1}^5 al_j$  refers to the sum total alliances, including the sum total alliances of type one to type five of an airline company  $i$ , and  $z$  is a vector of market conditions faced by the company ( $i$ ), and  $g$  refers to a comparative market condition ( $z \neq g$ ).

Hypothesis 2 tests the difference between the market conditions that the airlines of the three markets face. The equation model sustaining the hypothesis expressed as:

$$\Sigma (al)_i \neq \Sigma (al)_g \quad z=1, 2, \dots, 5, \quad z \neq g \dots (4.4)$$

Where  $i$  is an airline company,  $z$  refers to a market structure or condition,  $g$  is a comparative market condition.

Hypothesis 3 tests the parameters of the alliance developments. The structure model developed for testing the hypothesis is expressed as:

$$Y = f(A, Z, T, Q; \omega) \dots \dots \dots (4.5)$$

Where  $Y$  refers to the development of alliances,  $f$  denotes the functional relationship,  $A$  is a vector of a set of alliance variables,  $Z$  is a vector of the market conditions,  $T$  is the dummy variables of years, and  $Q$  is the total passengers carried by the carriers that influences the airlines' behaviors in formations, and  $\omega$  is a term of unobservable effects as an exogenous variable that may also influence alliances.

In particular, equation 4.1 is specified as:

$$Y = f\{A(\alpha_1, \dots, \alpha_5), Z(z_1, \dots, z_5), T(yr_1, \dots, yr_n), Q(q_1, \dots, q_k); \omega\} \dots \dots \dots (4.6)$$

Where  $\alpha_1, \dots, \alpha_5$  refers to the alliances of 1 to 5 types,  $z_1, \dots, z_5$  refers to the market conditions or abilities specified at 1 to 5 levels,  $yr_1, \dots, yr_n$  refers to the year dummy variables of from 1989 to 1999, and  $q$  is the numbers of passengers carried by carrier ( $i$ ) and  $k$  is a comparative carrier ( $i \neq k$ ).

In order to estimate the coefficients, model 4.1 is transformed into a residual equation form as:

$$\ln Y_i = \beta_0 + \beta_1 A + \beta_2 Z + \beta_3 T + \beta_4 \ln Q_i + \varepsilon_i \dots \dots \dots (4.7)$$

Where  $Y$  is the aggregate annual alliance formed of airline company  $i$ ,  $A$  is the overall total alliance, including each specific type of alliances of an airline ( $i$ ),  $Z$  is the specific market condition where the airline ( $i$ ) operating,  $T$  is a vector of year dummy variables, and  $Q_i$  is the total passenger traffic of the airline ( $i$ ).

### **Results from testing the hypotheses**

#### **Descriptive results**

More than a thousand (1,211) alliance agreements were signed by the major international airlines between themselves and with other airlines during the eleven years from 1989 to 1999 (see Table 2). British Airways, American Airlines and United Airlines were the top three of alliances. Air Canada, Qantas, Air France, Scandinavian Airlines and Lufthansa were also top airline alliances.

Table 2 Summary of the alliance activities of the 27 international airlines, 1989-99

<b>Airline</b>	<b>Rank</b>	<b>Total alliances</b>	<b>Airline</b>	<b>Rank</b>	<b>Total alliances</b>
BA	1	89	NZ	15	45
AA	2	81	DL	16	41
UA	3	77	SQ	17	34
QF	5	77	TG	17	33
AC	4	76	MH	18	36
SK	6	69	AZ	19	33
AF	7	62	CA	20	22
LH	8	55	NH	21	25
JAL	9	51	KE	22	22
SR	10	49	AL	23	20
KL	11	46	CDN	24	17
CO	12	45	AI	25	14
CX	13	38	VIR	26	9
NW	14	45	<b>Total</b>		<b>1211</b>

Note: airlines are descended according to the ranks assessed based on total alliances formed by the 27 airlines from 1989 to 1999

Table 3 shows generally the airlines of European Union had the largest number of alliances, airlines of North America had the second largest number, and followed by the airlines of Asia Pacific region.

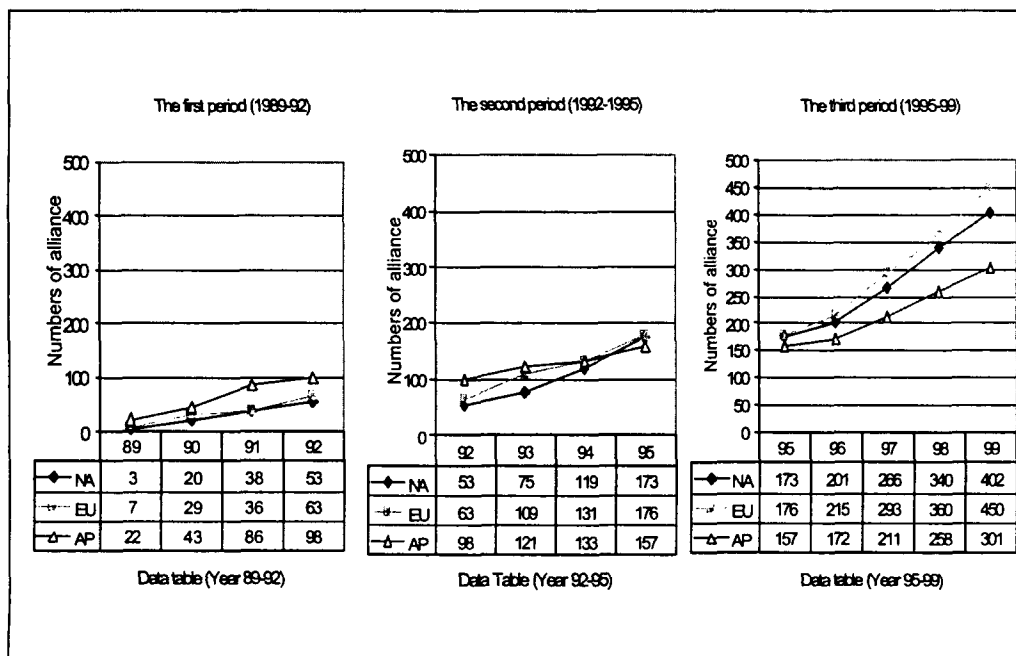
Table 3 Comparison of increases of alliance activities in the three markets 1989-99

Year	Northern America	European Union	Asia
1989	3	7	22
1990	17	22	21
1991	18	7	43
1992	15	27	12
1993	22	46	23
1994	44	22	12
1995	54	45	24
1996	28	39	15
1997	65	78	39
1998	74	67	47
1999	62	90	43
<b>Total</b>	<b>402</b>	<b>450</b>	<b>301</b>

Note: This is based on each year' new alliances of the 24 airlines (8 airlines from each market)

Also, a pattern of three distinct growth phases of alliance development was identified, which was specified from 1989 to 1992; 1992 to 1995; and 1995 to 1999. The number of strategic alliances increased differently at each period. The number of alliances in the second period of the development of airline alliance was 2.4 times of the first, and the number of alliances in the third period was 2.3 times of the second (see Figure 3).

Figure 3 Growth pattern of the alliance activities at the three markets 1989-99

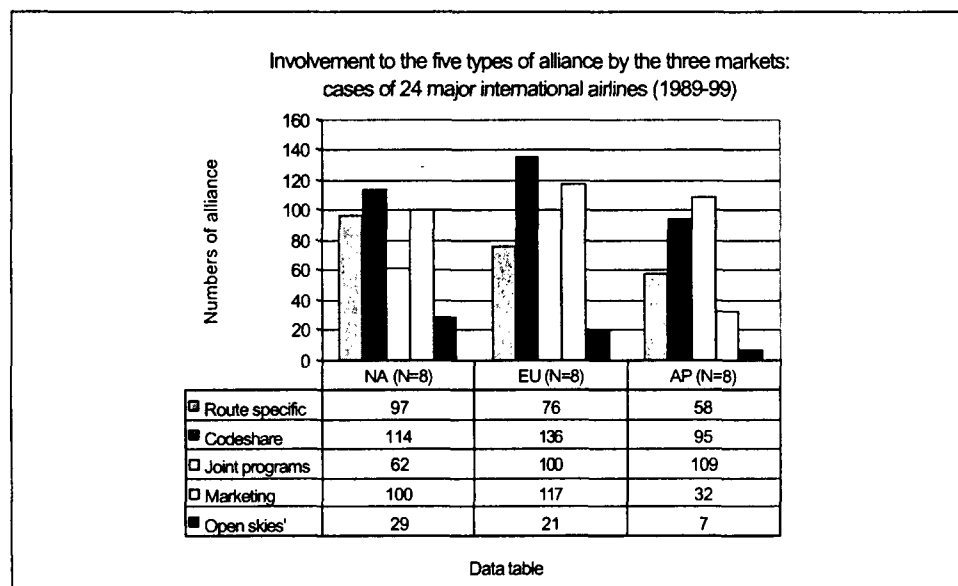


Note: these figures use accumulated data of alliances

The growth pattern also shows that the airlines of the Asia Pacific region were leading strategic alliance activities between 1989 and 1995. However, the airlines of Northern America and European Union had more rapid progress after the 12 European countries had completed the liberalization in 1993 and the US established 'open skies' regime after 1992.

Comparing the three markets, the airlines of EU developed the largest number of code share activities and marketing alliances, followed by the airlines of North America. The airlines of North America also had the largest number of new bilateral services. The airlines of the Asia Pacific region increased the largest number of joint programs from 1989 to 1999, and new bilateral services between the period of 1989 and 1994. The airlines of North America had the largest number of agreements signed under the 'open skies' (see Figure 4).

Figure 4 The three markets' involvement in the five types of alliance activities



Results of the descriptive studies lead to the tests of differences of the alliance development between the airlines with different markets conditions. These results also lead to the tests of effects of the market conditions on the development of airline alliances.

### Test alliance differences

Test results of  $H_1$  are presented in Table 4. Results show that there are significant differences between the three markets with the numbers of joint activities ( $\chi^2=21.1$ ,  $df=2$ ,  $p<0.001$ ), marketing alliances ( $\chi^2=29.7$ ,  $df=2$ ,  $p<0.001$ ), 'open skies' agreements ( $\chi^2=64.5$ ,  $df=2$ ,  $p<0.001$ ) and route specific services ( $\chi^2=15.6$ ,  $df=2$ ,  $p<0.001$ ). The mean ranks show that the airlines of North American engaged in alliances in total ( $h=149.2$ ) 5.6 points more than the airlines of the European Union ( $h=143.6$ ), and the airlines of European Union engaged in alliances in total 4.4 points more than the airlines of Asia Pacific region ( $h=139.2$ ). Results also show clearly that the airlines of North American and European Union significantly engaged in more marketing ( $\chi^2=29.7$ ,  $df=2$ ,  $p<0.001$ ) and 'open skies' alliances ( $\chi^2=64.5$ ,  $df=2$ ,  $p<0.001$ ) than the airlines of the Asia Pacific region.

However, there is no significant difference between the numbers of total alliances and code share activities of the airlines in the three markets. Nonetheless, the airlines of North American and European Union significantly engaged in more code share activities than the airlines of the Asia Pacific region, as the results of asymptotic significance and estimated mean ranks show. On the other hand, the airlines of the Asia Pacific region significantly forged more route specific services and joint activities than the airlines of North American and European Union. Test results of  $H_1$  agree with findings of the descriptive study, and support  $H_1$ .

Table 4: Differences of the development of strategic alliances in the three markets

Variables	Chi-Square df		Mean Ranks			Asymp. Sig.
			North America	European Union	Asia Region	P.
Total alliances	0.78	2	149.2	143.6	139.2	0.68
Route specific	15.6	2	113.6	113.3	143.5	0.00
Code share	2.69	2	141.8	156.1	136.7	0.26
Joint activities	21.1	2	116.9	143.9	168.9	0.00
Marketing	29.7	2	157.5	173.8	114.1	0.00
Open skies	64.5	2	173.5	168.5	105.7	0.00

### Test market condition differences

Test results of  $H_2$  are presented in Tables 5 and 6. Results from multiple tests based on the models designed generally show that the increased market abilities significantly contributed to the formations of alliances.

Table 5 shows the comparisons were made between the five models, in that the market conditions ( $z$ ) were 1,2,...,5 and  $z \neq g$ . Results show that the mean rank of each year's total new alliances are 133.3 after the markets were deregulated compared to 117.1 when the markets were regulated, and the mean rank of each year's total new alliances are 210.4 when the markets were fully liberalised compared to 133.3 when the market were deregulated ( $\chi^2=54.8$ ,  $df=4$ ,  $p<0.001$ ). The comparisons show that the airlines' numbers and features of alliances are significantly different when they were in different market conditions, except with merging the route specific services. Also, the airlines engaged in more alliances when the market abilities were increased.

Table 5 Estimation results: The difference between market conditions and the development of strategic alliance <sup>b</sup>

Variables	Chi-S X <sup>2</sup>	Df	Model 1 Mean ( <sup>a</sup> $z=1$ )	Model 2 Mean ( $z=2$ )	Model 3 Mean ( $z=3$ )	Model 4 Mean ( $z=4$ )	Model 5 Mean ( $z=5$ )	Asymp Sig. $\Sigma A_i \neq \Sigma A_j$ $\sum_{i=1}^5 (ah)_i \neq \sum_{j=1}^5 (ah)_j$
Annual allian'e	54.8	4	117.1	110.9	133.3	179.1	210.4	0.00
Route specific	4.4	4	55.7	45.9	60.1	57.8	47.4	0.36
Code share	23.8	4	66.3	59.5	63.9	85.7	101.5	0.00
Joint activities	12.3	4	56.1	40.16	51.35	49.8	70.7	0.02
Marketing	21.6	4	40.6	44.5	43.8	51.3	73.4	0.00
Open skies	5.1	4	*	16.0	16.0	19.3	23.9	0.17

<sup>a</sup>  $z$  is the market condition  $z=1,2,...,5$   $z \neq g$

<sup>b</sup> The assessment based on each year's new alliances of each airline

\*There was few 'open skies'.



The insignificant result for 'open skies' may be explained as that there were not sufficient numbers that could be executed by the statistical method of listwise regression in the comparison. In fact, few 'open skies' were formed when the air transport markets were still regulated (when  $z = 1$ ), and hence a 0 value can be applied so the result was highly significant ( $p < .001$ ).

Table 6 shows results from tests of the three models:  $L(l) \leq G(g)$ ,  $L(l) \leq G(g)$ , and  $L(l) \leq G(g)$  (where  $L=1,2,\dots,5$ , and  $L \neq G$ ) through t-tests. Results show the airlines formed numbers and types of alliances that are significantly different in different market conditions, which agrees with the results from tests of the five models. As indicated in Table 4, the test of Model 1 compares market condition one with five, Model 2 compares market condition two with three, and Model 3 compares market condition two with five.

Table 6 Estimation results: alliance developments with the five market conditions

Output <sup>c</sup>	Model one Significant $L(l) \leq G(g)$ $l=1$ $g=5$	Model two Significant $L(l) \leq G(g)$ $l=2$ $g=3$	Model three Significant $L(l) \leq G(g)$ $l=2$ $g=5$
Total alliances	0.00 (2.94)	Ns (2.99)	0.00 (7.08)
Route specific	Ns (2.25)	0.05 (1.92)	ns (2.14)
Code share	0.02 (1.87)	0.01 (1.64)	0.00 (2.92)
Joint activities	0.04 (2.74)	Ns (2.28)	0.01 (3.41)
Marketing	Ns (2.11)	Ns (2.17)	0.03 (3.19)
Open skies	Ns (1.0)	Ns (1.08)	0.01 (1.31)

<sup>c</sup> Results of t-test

ns = not significant

<sup>b</sup>The numbers in parentheses are means

Results from the test of Model 1 show airlines in market abilities measured at level five formed numbers of joint activities significantly larger than airlines in market conditions at level one (mean = 2.74,  $p < .01$ ). Results from tests of Model 2 show numbers of code share and route specific services developed are significantly different between the market conditions as two and three. Results from the test of Model 3 show the developments of total alliances are highly significantly different ( $p < .01$ , mean = 7.08) between the airlines in different market conditions. The airlines significantly had more numbers of joint activities ( $p < .01$ , mean=3.41), marketing alliances ( $p < .05$ , mean= 3.19) and 'open skies' ( $p < .01$ , mean= 1.31) with market abilities measured as level five, compared with that the market abilities as level two. All results from the multiple tests support  $H_3$ .

#### **Test linearity between market condition and alliance development**

Three models are structured in testing linearity ( $H_4$  and  $H_5$ ) and the test results are shown in Table 7. In Model 1, the coefficients of the estimation show that all the endogenous variables (the alliances) are significantly related to the exogenous variables (the market conditions), and the increase of market abilities leads positively to the formation of strategic alliances.

Before testing Model 2, stepwise regression analysis is executed with three variables entered, including year dummy variables, passenger traffic volumes, and market conditions. Stepwise analysis brings with results showing market conditions as the predictors of the developments of code share (Adj- $R^2$ :0.23,  $F=24.7$   $p < .01$ ), marketing alliances (Adj- $R^2$ :0.16,  $F=31$ ,  $p < .001$ ), 'open skies' (Adj- $R^2$ :0.18,  $F= 10$ ,  $p < .001$ ), and total alliances (Adj- $R^2$ :0.59,  $F=228.3$ ,  $p < .001$ ). The year dummy variables are significantly related to increases in the numbers of code share, joint activities, and total alliances. The variable of passengers carried is the predictor of the increase of route specific services.

As market conditions are not predictors for all the alliances, the second model therefore applies two stage-least squares regression, which enables the estimation to treat the market conditions as the explanatory factor but year dummy variables and passenger carried as instruments. Results of the estimation show market conditions

are the significant explanatory factor for both the increased total numbers and different features of alliances. Following this step, Model 3 is tested.

Results from Model 3 suggest market conditions are the alliance parameters other than the year dummy variable or the passenger volume of a carrier. The estimated coefficient on marketing alliances is  $\beta = 0.37$  ( $p < 0.001$ ) and on 'open skies' is  $\beta = 0.55$  ( $p < 0.001$ ), which indicates the increases of market abilities significantly leading to the development of airline alliances. Market conditions, as suggested by the beta values, are more important than the other two factors (year dummy and passenger carried) in contributing to the development of airline alliances. Importantly, the development of route specific services do not depend on market conditions but on year dummy variables. Thus,  $H_4$  and  $H_5$  are supported.

Table 7 Estimation results- developments of airline alliances with the market abilities

	Model 1 $Y = f(CN \bullet)$	Model 2 $Y = f(CN, YR, Q)$	Model 3 $Y = b^0 + b_1 CN + b_2 YR + b_3 Q$		
Variables	2 Stage least squares			Adjusted $R^2$	df
Total alliances	0.65*** (14.3)	1.1*** (9.2)	0.91** (14.8)	0.61	162
Route specific	0.43*** (7.9)	0.56*** (4.5)	0.73 (9.0)	0.35	160
Code share	0.59*** (12.4)	0.44*** (3.3)	0.79 (10.6)	0.45	162
Joint activities	0.27*** (4.7)	0.69*** (4.7)	0.32*** (3.6)	0.24	162
Marketing	0.65*** (14.6)	0.79*** (5.4)	0.68*** (8.05)	0.36	162
Open skies	0.66*** (15.4)	0.76*** (5.1)	0.69*** (8.3)	0.36	162

\*\* $p < 0.01$ , \*\*\* $p < 0.001$

( ) The number in parentheses are T value

For the model fit, Curve Estimates are applied. The estimation predicts the value of the increases of alliances from the increases of the market abilities through curve estimation. The estimation uses the predicted value and residual and the upper and lower 95% confidence limits for the predicted value (Norusis, 1993). The estimation also plots the curve based on observed and logarithmic value. Results from the Curve Estimations show the structure models 5 and 7 fit (see Appendix 3), and hence **H<sub>4</sub>** and **H<sub>5</sub>** are again supported.

Generally, results from tests of **H<sub>1</sub>** and **H<sub>2</sub>** show there are significant differences with the developments of strategic alliances between different market conditions. Airlines of North America and European Union are engaged in more numbers and dynamic features of alliances than the airlines of the Asia Pacific region. Tests of **H<sub>3</sub>** to **H<sub>5</sub>** bring with a positive linear relationship between the developments of alliances and the progresses of air transport markets towards liberalization. Results therefore suggest that market conditions are significantly important for the formation of alliances, particularly for the dynamic features alliances such as 'open skies' and global alliances. Countries, with market structures changing toward liberalization, enable airlines to form alliances that are more integrative, towards building up global brand reputation and competitiveness.

### **Conclusions**

The research commenced with an attempt to address the research problems of the development of airline alliances and the critical factors involved in the development. The descriptive results show that the three distinct growth phases of the development of airline alliances was in line with the three periods of the development of airline alliances: 1) fundamental agreements for new bilateral services and code share before 1992; 2) joint activities covering several areas between 1992 and 1995; and 3) dynamic alliances including global grouping and 'open skies' after 1995. These three periods corroborated the three stages of changes of the market conditions: regulation, deregulation and liberalization, suggesting airline alliances being affected by the critical factors of market conditions. The test of the hypotheses show that there is a significant difference between the development of airline strategic alliances with different market conditions. Airlines in liberalized markets involve larger numbers and deeper scope of alliances than the airlines in regulated markets. Also, there is a

linear relationship between the development of airline strategic alliances and the increase of market abilities or conditions suggesting more liberal markets lead to more alliances and integrative alliances formed in the markets.

Previous theoretical studies argue that Asian airlines have been seen as generally entering into few alliances with each other or with other airlines (Garnham, 1996, Hooper, 1997, Li, 1999 PC, 1998; Oum, 1998). Also, the liberalization process differs strongly between regions (Hooper, 1997; Oum, 1998). These arguments show a concern of airlines of the Asia Pacific region's involvement in strategic alliances and suggesting market abilities or conditions may affect airlines to involve with strategic alliances (Eleck, Findlay, Hooper and Warren, 1999; Oum, 1998, PC, 1998). This research through observations and empirical analysis has confirmed that the airlines of North America and the European Union are significantly engaged in more numbers and more dynamic features of alliances than the airlines of the Asia Pacific region. The findings of this research demonstrate these arguments are supported. Findings of this research also provided the diagnostic answers through the explanatory variables identified, and hence partly explain the alliance behaviors.

The findings of this research make a contribution to the strategic airline alliance literature, and also provide useful information for airlines' formation of strategic alliances. First it found that the airline industry has remarkably developed different features of alliances in various areas. The airline alliances are similar to, but also different from, the collaboration and consortia of other industries. The similarities are the nature of collaboration, which are involved by the horizontal bi-national groups and consortia, which are engaged by multiple partners of different countries, such as the Star Alliance and oneworld. The differences are the complex features, as well as, areas of cooperation. These areas of cooperation are linked to the characteristics of the industry and the motivations of airline alliances. These findings have implications for the development of concepts and features of airline alliances.

The strategic classification is a another contribution to studying the typology of strategic alliance, as little research has been done to specify current airline alliances, according to their overall nature and features. Also, the five types of airline alliances can range from simple alignments to integrative cooperation or from fundamental

focused coordination to integrative alliances. These clear definitions are useful for classifying and measuring airline alliance development and related studies. Further the measures created based on the theoretical investigations of the market abilities and conditions of North America, the EU and the Asia Pacific region would be useful for examinations on formation behavior of airline alliances and public policy.

This research identifies that the progress of market liberalization significantly contributes to the development of airline alliances. Regulation, on the other hand, restricts the development of an airline alliance, particularly the integrative features of alliances. As market conditions and trade abilities vary between countries, airlines significantly differ with entering numbers and forms of alliances. The market conditions also restrict airlines in choice of partners and features of alliance. Findings of this research can contribute to public policy making and ASAs, and air transport market liberalization.

Despite the contributions, there are some limitations in this thesis. First, the total number of airline alliances up till 1999 reported by the Airline Alliance Survey is different from the result of the exploratory study conducted by this thesis. According to the Airline Alliance Survey (1999), there were a total number of 856 alliances formed between the world international airlines in the 1990s. This research recognizes that there are 1211 alliances formed by the 27 major international airlines within themselves and with other airlines from 1989 to 1999. This number was accumulated based on each year's new alliances of the international airlines and these agreements were reported by the Airline Business monthly issue from the year of 1990 to 1999. This number of alliances may not be exactly the number of alliances that the airlines are upholding so far, as some airlines were de-allied with each other or abolished the agreements during this period of time. However, it can be seen through the observation that most of the alliances have been stable. It also identified by Oum et. al. (2000) that the survival rates of airline alliances have been improving very rapidly during the last decade, and this trend is likely to continue in the future.

The future prospect of airline strategic alliances is seen as increasing and stable. Oum et. al. (2000) indicate that the emerging global alliance groups being formed by several major carriers residing in different countries and continents are expected to be

strengthened over time, due to the increasing market shares, operation revenue, consumer benefits and economic welfare of society. Thus this study is expected to become a milestone in studying strategic alliances and the development of airline alliances in the future

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**Appendix 1 Frameworks for the strategic classification of the five types of airline alliances**

<b>Types</b>	<b>Estimates</b>
<b>Type one</b>	Route specific alliance refers to the prime Bilateral Air Service Agreement signed between two countries, to enable flights between cities of the two countries, or boost capacity or frequencies of flight service between cities of the two countries (or may grant beyond rights, to use intermediate stops or beyond services). To this extent, the bilateral agreement of six weekly Singapore-New York services signed between Singapore and USA enables three flights agreement operated via Brussels and three via Frankfurt is an example. A trading beyond right between Korea and India enables Korean Airlines to fly from India to Europe and Egypt, in return for the right to Air India to fly from Seoul to the United States is another example.
<b>Type two</b>	Code share refers to block space agreements, or code share on a number of city-pair markets. These agreements often involve one airline buying blocks of seats on the other's flights and reselling them. ie. Qantas and Air Nuigini operate a route-specific alliance, which involves code sharing on flights between Cairns and Port Moresby and Mount Hagen. The agreement between United Airlines and Ansett enables passengers to travel to Sydney on a United Airlines flight and connect with Ansett flights to eight Australian cities. Code share also involves one airline's designator code is shown on flights operated by its partner airline. Code-sharing agreements allow each airline involved providing services with its partner's flights even though it does not operate the aircraft itself. For Example, Canadian Airlines and Qantas have a code-sharing agreement on the Vancouver- Honolulu- Sydney route where Canadian serves the Vancouver-Honolulu section and Qantas serves the Honolulu-Sydney section of the route.
<b>Type three</b>	Joint activities generally refer to joint venture, collaboration or cooperation including joint purchasing of aircraft/fuel, equity investment or stake purchase, aircraft leasing, maintenance, staff training, labor agreement, joint operation, which is within the areas of cooperation in joint use of ground facilities, coordination in ground handling, coordination of flight schedules.

**Appendix 1 Frameworks for the strategic classification of the five types of airline alliances (Continued)**

<b>Types</b>	<b>Estimates</b>
<b>Type four</b>	A marketing alliance involves cooperative agreements on ticketing service, share of CRS, FFPs and joint advertising, including milestones such as Star Alliance. To this extent, a marketing alliance overlaps with joint operation, as the marketing alliance also involves joint use of ground facilities, coordination in ground handling, coordination of flight schedules and on-line and interline co-operations under the agreement of global alliances. Marketing alliance includes oneworld, Star, Qualifier, Air France/Delta Global Wings (Northwest/KLM), and other similar types but regional based alliances

**Type five** 'Open skies' refers to the alliances initiated by US between some American, EU and a few Asian countries. The alliances, formed under the US bilateral 'open skies' policy, are basically commercial alliance in nature, being more integrative in levels and areas of cooperation, compared with the other types of alliances. The memorandum of understanding normally leads to code share agreement on international and domestic flight, reciprocal FFP, lounge access, though check-in, integration of boarding procedures, computer reservation system linkage, joint marketing and sales programs 'Open skies' also involve single aviation market, free access to the markets, full traffic right, may also grant anti-trust immunity, but so far a few countries have been granted (Also see the notes of the 'open skies' policy).

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**Appendix 2 Open skies policy**

<b>Items</b>
<ul style="list-style-type: none"> <li>• Open entry on all routes between the bilateral partners;</li> <li>• Unrestricted rights for partner airlines to operate between any international gateways in the United States and participating countries, including to intermediate and beyond points;</li> <li>• Unrestricted capacity, frequency and aircraft on all routes;</li> <li>• Flexibility for airlines in setting fares within certain guidelines;</li> <li>• Liberal charter and cargo arrangements;</li> <li>• The ability of carriers to convert earnings into hard currency and return those earnings to</li> </ul>

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their homelands without restriction;

- Open code-sharing opportunities;
  - Rights for carriers to perform their own ground handling in the partner country;
  - The ability of carriers to enter freely into commercial transactions related to their flight operations; and
  - A commitment for non-discriminatory operation of, and access to, computer reservation systems
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Sources: Airline Business, 1992; Subcommittee on Aviation 1997.

### Appendix 3 Curve estimates- Development of strategic alliances with the change of market conditions (Model prediction)

Independent: MKTCO						
Dependent	Mth	Rsqr	d.f.	F	Sig	b <sub>0</sub> b <sub>1</sub>
BILAT	LOG	.158	280	52.53	.000	1.8989 3.8416
CODE	LOG	.267	280	101.92	.000	-.3879 6.0314
JOINT	LOG	.053	280	15.62	.000	2.9361 2.3092
MARKET	LOG	.325	280	135.10	.000	-1.5017 5.5676
OPEN	LOG	.324	280	134.34	.000	-.5247 1.2196
TOTALAL	LOG	.327	280	136.01	.000	1.7845 19.2356

### Appendix 4 Curve estimates- Development of strategic alliances with increase of market abilities (Model fitting)

Name	Label
FIT_1	Fit for BILAT1 with COND1_5 from CURVEFIT, MOD_5 LOGARITHMIC
FIT_2	Fit for CODE1 with COND1_5 from CURVEFIT, MOD_5 LOGARITHMIC
FIT_3	Fit for JOINT1 with COND1_5 from CURVEFIT, MOD_5 LOGARITHMIC
FIT_4	Fit for MKTA1 with COND1_5 from CURVEFIT, MOD_5 LOGARITHMIC
FIT_5	Fit for OPEN1 with COND1_5 from CURVEFIT, MOD_5 LOGARITHMIC
FIT_6	Fit for TO_AL with COND1_5 from CURVEFIT, MOD_5 LOGARITHMIC

# Airport Privatization Policy and Performance Measurement in Korea

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## Abstract

Korean government is considering the reformation of airport operating system. The objective of the reformation is to improve the economic efficiency related to airport operation. For doing this, it is necessary to know the best practices on various dimensions of airport operations, and it is subsequently required to evaluate the performance of airport operation. This study is to measure and compare the operating performance of each airport in Korea. In Korea, there are 17 airports opened to civil aviation and these airports offer scheduled flight service. Five of them are able to serve international flights and other twelve airports are for domestic flight service only. The ownership of all those airports belongs to central government. The ministries responsible are the Ministry of Construction and Transportation and the Ministry of National Defense. The autonomous governmental organization, KAA(Korea Airports Authority) is responsible for the operation and management of civil airports without ownership, excluding Incheon International Airport which opened March 2001. The productivity and efficiency, unit costs, and financial status of each airport in the system will be measured and compared. Some interpretations on the results of performance measurement are tried and some recommendations are suggested based on the interpretation of performance indicators of this study.

Keywords: Airport Performance, Workload unit, Airport operating cost

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## **1. Introduction**

The air transport industry has been experiencing globalization and liberalization, and it is foreseen that this trend will keep going on into the future. This means that the international airlines will be able to choose its base airport with greater freedom in the future. It will lead an airline to consider more the economic advantage than nationality or national boundary when it chooses the base airport or composes service network. So, the competition between international airports to attract airlines will be severe. For relatively small domestic airports, the economic efficiency related to their operations is more important, because they should compete not only with other airports but also with other modes of transportation. Airport owners and operators who realize this situation are trying to improve the economic performance in operating airports in order to provide the service efficiently and effectively. In an era where airports are subject to more competitive pressures, it is more required to know what their performance is.

It is necessary to measure the performance of airport operations for each major players involved in air transport industry such as airlines, airport operators and regulators. Airlines need to evaluate the airport's performance in choosing their base airport to operate with low costs and high level of service. Since airport operators want to improve their service level offering lower user charge to attract airlines, they are keen to identify the strong performers in the industry and to improve their own practices of operation, as airports become commercially oriented. To achieve such an objective, it is prerequisite to have the information about their own performance and other airports'. The regulators also need to have some performance information concerned with airport operation when they make the policy to lead their air transport industry more competitive. Anyway, the usefulness of performance measurement in airport operation cannot be disregarded.

The objective of this study is to measure the operating performance of the airports serving to airlines' flight operation in Korea. Costs performance, productivity and efficiency, and financial status of each airport in the system are to be measured and evaluated. Any possible advice derived from such an analysis, concerned with the improvement of economic efficiency in operating airport system is presented.

The methodology of airport performance measurement is classified in two categories; total factor productivity methods and partial indicator methods. This study will utilize partial indicator methods, because we are interested in the performance indicators related to unit costs, productivity, revenues, and profits.



## 2. Korean Airport Systems, Ownership, and Operation

In Korea, there are 17 airports that offer scheduled air transport services, eight international airports and nine domestic airports. The ownership of all these airports belongs to central government: some of them are controlled by the MOCT (Ministry of Construction and Transportation) and the others are controlled by the MOND (the Ministry of the National Defense). The civil aviation airports except Incheon International Airport are operated by Korea Airports Authority (KAA), which is the independent governmental body. Incheon International Airport, which is recently opened in March 2001, is operated by another independent company named Incheon International Airport Corporation, which is also owned by central government of Korea. Military airports are operated by the Army, Air Force, Navy, or US Air Force.

KAA is the autonomous governmental organization responsible for operating and managing civil airports without ownership. The military airports, which the airlines are allowed to use, are jointly operated by KAA and military authority. The airport use agreement between the Ministry of Construction and Transportation and the Ministry of National Defense is established for the civil use of military airports. The military authority is usually in charge of operating landing field and air traffic control around airport, and KAA is in charge of the civilian terminal operation and ramp operation for civil aircraft. For both civil and military airports, the private sector participation in airport operation is limited to passenger and cargo handling, a small portion of commercial activities in the terminal building, and ramp service for the civil aircraft.

Table 1 shows the summary of Korean airports' ownership and scale (the number of passengers handled annually). The airport operational works commissioned from central government to KAA are ranged as follows.<sup>1</sup>

(i) Maintenance and operation of landing field, including runway, taxiway, and ramp area for aircraft movement; (ii) Management of passenger and cargo terminals; (iii) airport security, fire fighting and accident handling; (iv) operation and maintenance of Instrument Landing System, Air Navigation facilities, and communication systems; (v) environmental protection - including noise problem, water and air pollution.

Almost all of the operational works commissioned to KAA are administered directly by KAA employees or airlines. The duty free shops are mainly operated by the Korea Tourism Authority, which is another governmental organization, and only immaterial portion of duty free shopping and the commercial activities in the passenger terminals are conducted by private sector entrepreneur.

Table 1

Ownership and Control of Korean Public Airports (2000)

Rank	Airport	Ownership & Control	Passenger volume(thousand)
1	Gimpo Int'l	MOCT (Ministry of Construction and Transportation)	36,637
2	Gimhae Int'l	Air Force	9,358
3	Jeju Int'l	MOCT	9,126
4	Gwangju Int'l	Air Force	2,382
5	Daegu Int'l	Air Force	2,241
6	Ulsan Domestic	MOCT	1,377
7	Jinju Domestic	Air Force	880
8	Pohang Domestic	MOCT	802
9	Yeosu Domestic	Navy	669
10	Cheongju Int'l	Air Force	529
11	Gangnung Int'l	Air Force	515
12	Mockpo Domestic	Navy	338
13	Gunsan Domestic	US Air Force	271
14	Sockcho Domestic	Army	134
15	Yeochon Domestic	Air Force	133
16	Wonju Domestic	Air Force	84

Source: Korea Civil Aviation Development Association, Aviation Statistics, Seoul, Korea, 2001

The airlines or civil aircraft operators pay some fees to the Ministry of National Defense for using military airport facilities, building and land. The civil aircraft landing fees are charged by the Ministry of Construction and Transportation. However, the revenue of landing fees must be used for the landing field maintenance and operation. The passenger and cargo terminal and accompanying facilities to be used for the ground handling of civil traffic at military airport are constructed and maintained by the Ministry of Construction and Transportation, while KAA and airlines are responsible for the terminal operation.<sup>2</sup>

Now, Korean government opened New Seoul Airport in March 2001, which is named as Incheon International Airport (IIA). According to dramatic increase of air transport demand in 1980's, the Korean government recognized the urgent need to expand the airport capacity for Seoul area. However, the existing Gimpo Airport has the limitation to be expanded. The master plan for the development of the IIA was announced in 1992 and followed by the ground breaking in the same year. IIA opened for the first phase operation in March 2001. Incheon International Airport Corporation whose 100% stake holder is Korean central government is in charge of the airport operation. The airport has an annual capacity of 170,000 flights, 27 million passengers, and 1.7 million tons of cargo annually. On completion of the last phase beyond 2020, IIA will have the capacity of handling 100 million passengers using four runways. On opening IIA, all the scheduled international flights which had been operated at Gimpo airport, moved to IIA. Now, Gimpo airport is operating domestic flights for Seoul area and some non-scheduled international flights.

### 3. An Attempt to Improve Airport Operation System in Korea

<sup>1</sup> Article 7 of "The Law of Korea Airport Authority"

<sup>2</sup> Article 4,5,7,11 of "Agreement for the civilian use of military aerodrome", Korean Government, 1998

Almost all the areas of Korean economic system have been undergoing renovation motivated by IMF (International Monetary Fund) control since the currency crisis in late 1997. The Planning and Budgeting Board (PBB), which has published the plans concerned with the renovation as a newly established governmental agency, made the laws to privatize the public enterprises. The law to corporatize and privatize airport system is one of them.

It has been generally recognized that the current system of airport operation in Korea is very inefficient and the level of service quality is relatively low. Gimpo international airport has been the only one that recorded profit, and all the other airports have been suffering deficit continuously. Even in Gimpo, the portion of non-aeronautical revenue among total revenue is very low, which means that the financial performance of airport operation cannot be considered desirable.<sup>3</sup>

The Korean government has been trying to promote the private investment for public facilities, with the incentives that the investor can operate the facilities and earn profit. The participation of private sector for funding and operating public facilities may lead to the improvement of economic efficiency. This privatization concept is being applied to airport systems. The cargo terminals, fueling systems, and electric power systems for IIA were constructed by private investors. The terminal building and car parking facilities for local domestic airports are also considered as the facilities to attract private investors.<sup>4</sup> In addition, Korean Government changed the legal status of KOACA from governmental authority to public corporation and named it "IIA Corporation" in February 1999, in order to facilitate the privatization process of the airport. IIA Corporation is endowed to operate the IIA as well as keep going in construction.

Korean central government is also currently trying to change the legal status of KAA to another public corporation in order to speed up the privatization process of existing airports. Even though the government has not finalized its detailed proposal, the conceptual outline of the idea for KAA corporatization can be summarized as follows:<sup>5</sup> (i) KAA's legal organizational status is changed from autonomous governmental authority to public corporation, temporarily named "Korea Airport Corporation (KAC)", (ii) The capital of KAC is composed of shares, (iii) KAC will be allowed to issue the corporate bond, (iv) KAC will be allowed to commission the right of airport operation to other organizations, (v) KAC may be allowed to utilize international debt financing.

The ultimate purpose of such a renovation is to improve the economic efficiency of airport operation. Through the performance measurement for each airport, a clue for optimistic strategies for that purpose can be generated.

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<sup>3</sup> KAA, Detailed Income Statement, 1997

<sup>4</sup> KOACA, Introduction to Incheon International Airport Project, Seoul, Korea, 1997

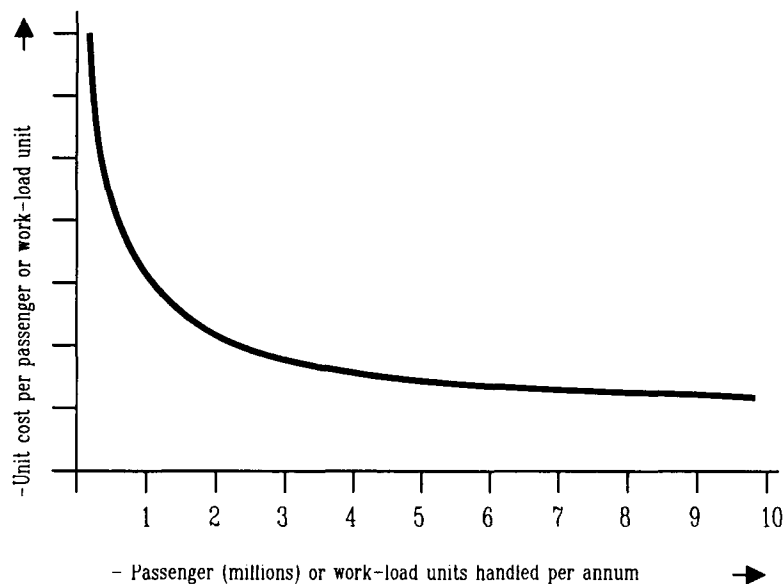
<sup>5</sup> Korean MOCT, A Draft of the Law Related To KAA Corporatization, Seoul, Korea, April, 1999

#### **4. Performance Measurement for Korean Airports**

##### *4.1. Demand levels of each Airport*

It is generally accepted that the results of economic performance of airport operation, are mainly influenced by the size of the airport traffic. That is to say, 'economies of scale' is applied to the performance of airport operation. Through the studies of British Airports in 1980s, Doganis (1992) found that unit costs fall sharply as traffic demand increases, particularly up to 1.0 or 1.5 million passengers. He also pointed out that unit costs flatten out and do not seem to vary much with airport size, as traffic grows beyond a level of about three million passengers a year (see figure 1).

As shown in table 1, the demand level of each airport in Korea is various. Gimpo International Airport has the biggest demand, ranked within top 20 in the world in the aspect of the volume of annual traffic. Jeju and Gimhae Airport can be considered as big airports too. They handled about 10 million passengers annually. Jeju airport is owned by MOCT and Gimhae airport belongs to Korean Air Force. Daegu and Gwangju airports have demand level between two millions and three millions, and these two airports belong to Korean Air Force. Ulsan and Pohang airports recorded between one million and two million of annual passenger demand. The other airports can be considered as small airports that have less than one million passengers as annual demand.



source: Doganis(1992), P.50

Figure 1. Airport Long-Run Costs Curve

#### 4.2. Input Data for Performance Measurement

The KAA annual financial report for 1997 is utilized as database for the study. As Korean economy started to be affected by the currency crisis from December 1997, the air transport demand in 1998 has sharply fallen. Though the demand for international air transport in the year 2000 has recovered to the level prior to IMF control situation, the domestic transportation has been well behind. So, this study utilizes the data of the last year without the effect of the currency crisis in Korean economy.

The study begins by describing the revenue and cost structures of airports. The typical classification of airport costs and revenues and the structure of costs and revenues of Korean airports are introduced (Table 2, 3).

Table 2.

Typical Classification of Airport Revenues and Costs Structure

REVENUE

Aeronautical Revenues:

Landing Fees

Passenger Charges

Aircraft Parking Fees

ATC Charges

Other Charges (Lighting, Airbridges, Fueling Service, etc.)

Non-Aeronautical Revenue:

Rents or Lease Income

Concession Income

Direct Sales

Car Park Revenue

Recharge

Non-airport related activities (e.g. Land Development)

Other Non-Aeronautical Revenue

EXPENSES

Labor Costs

Capital Charges (Depreciation and/or Interests)

Services, Equipment and Supplies

Maintenance and Repairs

Administration and Other

Source: Doganis, R. the Airport Business, Routledge, 1992

Graham, A. "Airport Economics and Performance Measurement", Airport Economics and Finance Symposium,  
University of Westminster/Cranfield University, 1998

Table 3.

KAA, Airport Revenues and costs structure

1. Operating Revenues

(1) Rental (or Lease)

- Lands
- Buildings
- Facilities
- Equipment
- (2) Aeronautical Revenue
  - Landing fee
  - Aircraft parking charge
  - Ramp charge
- (3) Landside facility user charge
  - Car park
  - Waiting Room charge
- (4) Commercial Revenue (Shops & Snack Operated by KAA)
- (5) Other Revenue
- 2. Operating Expense
  - (1) Facility Operation and Maintenance
    - Labor Costs
    - Other Expenses
  - (2) Costs for direct commercial activities
    - Labor Costs
    - Other Expenses
- 3. Sales & Administrative Costs
  - (1) Staff Costs
  - (2) Overhead expenses

*Source:* Statement of Accountings, KAA 1997

#### *4.3. Measurement of Overall Costs Performance*

The scale of traffic volume at an airport significantly affects the unit costs, which is represented by total operating costs per WLU (Work Load Unit). Total operating costs include all the cost items related to airport operation. However, the depreciation costs of runway and taxiway, and interest costs are not included in KAA's statement of accountings. The expenses accrued from providing ATC services at airport control tower are not included either, because this service is provided by MOCT without charging to KAA.

Table 4 shows the total operating costs per WLU for each airport, as unit costs. Figure 2 depicts these

data to show the variation of unit costs according to traffic volume. The unit total costs of Korean airports decrease sharply as traffic volume increases, until three million WLU of annual demand. This is the same trend with Doganis' study. Figure 3 is to show this trend clearly by presenting the graphics of unit costs of the airports which have traffic demand less than three millions only, excluding large airports such as Gimpo, Gimhae and Jeju. As shown at the graph, Chungju and Daegu have extraordinarily higher unit costs deviating from normal pattern. Chungju opened new passenger terminal a few years ago, which is relatively large for current demand level, and this resulted in high unit costs. Daegu was conducting construction work for runway expansion sharing construction costs with Air Force, and this caused high unit costs.

Table 4.

Costs per WLU (Unit: Korean Won)

Airport	Total operating costs per WLU
Gimpo Int'l	1,556
Jeju Int'l	1,617
Gimhae Int's	1,824
Gwangju Domestic	1,677
Daegu Domestic	5,479
Ulsan Domestic	2,541
Pohang Domestic	1,844
Yeosu Domestic	3,894
Jinju Domestic	2,429
Gangnung Domestic	2,372
Gunsan	4,321
Sockcho Domestic	6,414
Yechon Domestic	3,566
Chungju Int'l	17,283
Mockpo Domestic	8,786
Wonju Domestic	16,294



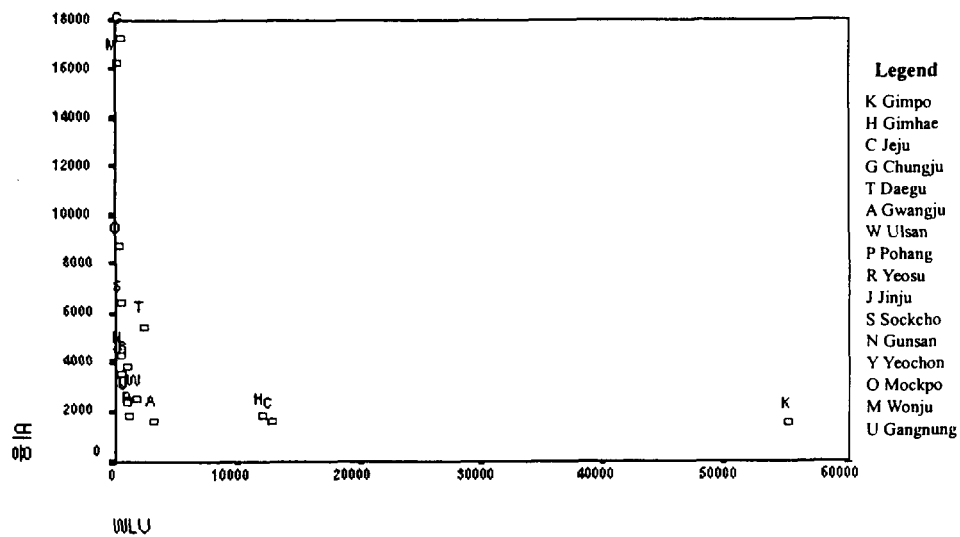


Figure 2. Unit cost and demand level

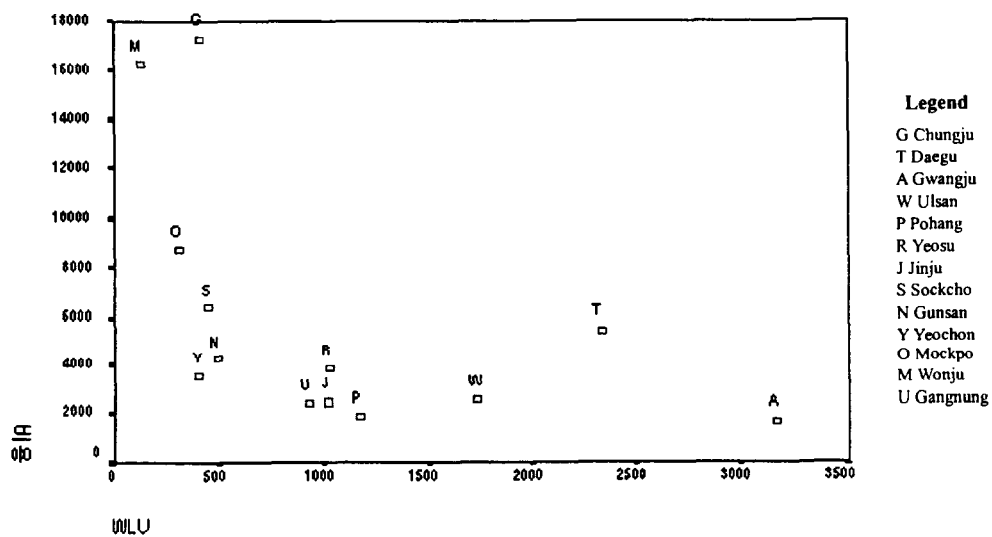


Figure 3. Unit Cost for small Airports

It is found that Ulsan recorded higher unit cost than Pohang, in spite of slightly higher traffic demand. While Ulsan Airport is a pure civil airport under control of MOCT, all the facilities of which are operated by KAA, Pohang belongs to Ministry of National Defense. As KAA does not operate landing field facilities at Pohang Airport, it pays part of runway maintenance costs to Military Units which operate the landing field of the airport. Almost same kind of result is obtained through comparing total unit costs

between Yeosu and Jinju, whose traffic demands are in almost same level. Jinju belongs to Military, and Yeosu belongs to KAA. Conclusively, it can be said that the civil use of military airport is more cost efficient for KAA, under the condition of current Military Airport Use Agreements between MOCT and MOND. According to another study of comparing the unit costs accrued to KAA from civilian use of Military aerodrome, it is found that common use of Air Force Aerodrome facilities resulted in lower unit costs, than that of Army Aerodrome. That may be because the Air Force provides higher quality and wider range of service for flight operation than Army. ( )

#### *4.4. Labor Productivity*

Table 5 is to show the indicator of labor productivity. Labor productivity is measured by labor costs per WLU, WLUs per employee, or revenue per employee. Through comparing labor costs per WLU of each airport, 'economies of scale' is also found. Larger airports recorded lower labor costs per WLU. The comparison of WLUs per employee of each airport represents same result as that of labor costs per WLU. The common use of military airport shows some cost advantages. Military airports show better performance than pure civilian airports, because KAA assigned smaller number of employees to military aerodrome where KAA does not have to administer the landing field operations. Revenue per employee also shows 'the bigger, the better' trend. Gimpo Airport, which has an incomparably large volume of demand, ranked number one in the aspect of revenue per employee by a striking difference. Through comparing the revenue per employee between Jeju and Gimhae, it is found that Gimhae shows better record by significant difference. This may be because Gimhae Airport, which has larger terminal building, had more rental income than Jeju Airport. Overall the military airports show more favorable performance than the airports controlled by MOCT. This is because the military airports have the advantage of fewer employees. However, it is also suspected that KAA was not successful in commercial activities at its own airports in spite of more controllable situation than at military airport.

Table 5.

Labor productivity Indicators (Unit: Korean Won for labor costs and revenue)

Airport	Labor costs per WLU	WLU per employee	Revenue per Employee
Gimpo Int'l	636	42,676	138,567,242
Jeju Int'l	678	42,303	43,580,101
Gimhae Int's	774	35,833	58,693,217
Gwangju Domestic	868	38,000	36,295,339
Daegu Domestic	838	35,196	29,030,086
Ulsan Domestic	1,627	15,853	10,881,706
Pohang Domestic	1,154	29,717	19,552,201
Yeosu Domestic	2,732	12,679	9,644,215
Jinju Domestic	1,368	24,262	18,572,694
Gangnung Domestic	1,404	27,147	16,133,184
Gunsan	2,489	11,302	8,975,303
Sockcho Domestic	4,115	9,313	5,589,799
Yeocheon Domestic	2,190	16,583	9,787,947
Chungju Int'l	8,533	3,311	9,176,832
Mockpo Domestic	6,044	5,774	4,257,889
Wonju Domestic	10,207	5,040	7,430,926

#### 4.5. Capital Productivity

The productivity of capital employed is considered very difficult to measure because it is not easy to identify and assess the net value of an airport's assets. Fortunately, KAA published officially the estimated value of assets in each airport. This study utilizes the value as a base to calculate the indicator of capital productivity. Table 6 shows the estimated asset value of each airport and the capital productivity indicators; WLU per million Korean Won of estimated asset value and total revenue per million Korean Won of estimated asset value.

An interesting fact was discovered through comparing the indicators about WLU per asset value. That is, Gimpo Airport which ranked first by unit costs and labor productivity, ranked last. That is because Gimpo Airport is located around Seoul area, where the value of land is extraordinarily higher than any other places in Korea. On the contrary, Yecheon Airport, which is located in mountainous countryside, recorded best performance in capital productivity. This indicator seems to be mainly influenced by the value of the land where the airport located, because the value of land has very wide range of variation from location to location in Korea.

Table 6.

Asset Value and Capital Productivity

Airport	Asset value (Million Won)	WLU/million won asset value	Total revenue/million won asset value
Gimpo Int'l	1,248,300	44	143,307
Jeju Int'l	96,700	131	135,201

Gimhae Int's	117,400	101	164,980
Gwangju Domestic	12,500	252	241,001
Daegu Domestic	11,100	209	172,611
Ulsan Domestic	9,300	185	127,538
Pohang Domestic	4,500	257	119,452
Yeosu Domestic	11,100	92	70,376
Jinju Domestic	4,800	212	162,511
Gangnung Domestic	6,200	148	88,472
Gunsan	8,800	55	43,856
Sockcho Domestic	6,500	68	41,278
Yeochoon Domestic	900	442	261,012
Chungju Int'l	-	-	-
Mockpo Domestic	5,600	54	40,297
Wonju Domestic	-	-	-

#### 4.6. Revenue Generation Performance

The major indicator to measure the revenue generation performance is total revenue per WLU. This indicator can show the overall performance of an airport in the aspect of generating revenue. Gimpo Airport where they run relatively big duty-free shop, several restaurants and shops, recorded best performance. However, for the other airports, this indicator does not show the trend compatible with traffic volume of each airport. For example, Chungju and Wonju marked relatively good record in spite of very low level of demand. There are some suspected causes to such an unexpected results. First of all, the passenger charges are not included in airport revenue in Korea, since they come into government. This means that the airports where they have higher traffic demand and more passengers per flight, do not have the advantage in revenues from passenger charges. In addition, since the two airlines of Korean Air and Asiana Air whose fleets composed of mainly large aircraft, operate large aircraft for small airports, subsequently small airports can get high landing fees compared to demand level. This is why Chungju and Wonju had relatively high value of revenue generation indicator.

One needs to break down total revenue into two components, aeronautical and non-aeronautical revenue. However, the accounting practice of KAA does not allow this clearly, because there are some rental income items coming from mixed activities of aeronautical purposes and non-aeronautical purposes. In addition, the passenger charges which belong to aeronautical revenue, are not included in airport revenue, as stated above.

Table 7.

Revenue Generation Performances (Unit: Korean Won)

Airport	Total Revenue per WLU
Gimpo Int'l	3,246
Jeju Int'l	1,030
Gimhae Int's	1,637
Gwangju Domestic	955
Daegu Domestic	824
Ulsan Domestic	686
Pohang Domestic	657
Yeosu Domestic	760
Jinju Domestic	765
Gangnung Domestic	-
Gunsan	794
Sockcho Domestic	600
Yeocheon Domestic	590
Chungju Int'l	2,771
Mockpo Domestic	737
Wonju Domestic	1,474

\* non-aeronautical revenue/WLU

#### 4.7. Profitability Measures

KAA recorded total revenue about 223 billion Korean Won and 5.9 billion Korean Won as an operating profit in 1997. But in understanding this figure, it should be considered that the big cost items of depreciation and interest are excluded and passenger charges are not included in revenue. Depreciation costs for runway and interest costs are not accounted in KAA's income statement. According to table 8, while all the other airports suffered deficit, only Gimpo Airport recorded profit. Gimhae showed 0.9 of revenue/expenditure ratio and the others marked very undesirable performance.

Table 8.

Revenue/Expenditure Ratio

Airport	Rev/Ex
Gimpo Int'l	2.09
Jeju Int'l	0.64
Gimhae Int's	0.90
Gwangju Domestic	0.57
Daegu Domestic	0.15
Ulsan Domestic	0.27
Pohang Domestic	0.36
Yeosu Domestic	0.20
Jinju Domestic	0.32
Gangnung Domestic	0.25
Gunsan	0.18
Sockcho Domestic	0.09
Yeocheon Domestic	0.17

Chungju Int'l	0.16
Mockpo Domestic	0.08
Wonju Domestic	0.09
Sachon	0.32

## 5. Conclusions – Recommendation to improve the efficiency of Airport Operation

As conclusions, this chapter will suggest some recommendations to improve the economic efficiency of airport operation in Korea, based on the results of performance measurement in this study. First of all, it is required for KAA to add some management accounting practice in its accounting system. It is useful to allocate costs to the major cost areas associated (or cost centers). There are four major areas; (1) the landing area, (2) the terminal, (3) hangar area, and (4) other non-aviation-related areas (Gesell, 1992). The information obtained from such an accounting practice can be utilized for the performance measurements of specific area in airport. For example, if labor costs for terminal management are available, it is possible to measure labor productivity in operating terminal. The cost accounting by cost centers is also useful to determine the rate of user charge based on each service costs, which is a pricing concept recommended by ICAO.

According to the revenue structure of each airport, the proportion of commercial revenue is very small, especially for Gimpo, Gwangju, Jeju, and Gimhae Airport. In Gimpo Airport, which handled 55 million WLU annually, aeronautical revenue is more than 60% in its revenue structure, without including passenger charges. If passenger charges are included, the portion of aeronautical revenue may go up to 70% or more. This means that non-aeronautical revenue takes less than 30% of total revenue, which is a very low percentage compared with similar size of airports in Western Europe or North America. The large airports where they have more than several million WLUs as an annual traffic volume, are usually expected to have 50% as a ratio of non-aeronautical (commercial) revenue to total revenue. In this regard, Gwangju, Jeju and Gimhae Airport seem to have bad records of commercial revenue, too.

Especially, Jeju Airport where they have more than 10 million WLU as annual demand, should have earned more commercial revenue per WLU, compared with other airports in Korea. It earned about 300 Korean Won per WLU as commercial revenue, while Gimhae Airport with similar size of traffic demand, recorded about 550 Korean Won. Gwangju Airport also has to try to increase non-aeronautical revenue because it recorded relatively low performance indicator of revenue generation among similar size airports. However, the total revenue per employee is recorded relatively high for Gwangju Airport. Therefore, it seems to be desirable for KAA to invest for commercial activities at this airport. Soekcho Airport which belongs to the group of small airports with 447 thousand WLU as annual traffic volume, ranked last for the performance of non-aeronautical revenue per WLU. As Soekcho city is one of the famous resort area in Korea, it is expected that Soekcho Airport can get more sales revenue through commercial activities in terminal building than other small airports. (

MOCT has been constructing some civil airports to quit co-using the military aerodrome in Gwangju-Mockpo, Sockcho-Gangnung, and Junju area. This is because there have been some serious safety problems and constraints on obtaining slots from the military. However, in terms of economic efficiency, it is desirable to use military airports and enjoy the cost advantage as long as possible. The development of new airports to replace military aerodrome can be effective only in the cases of safety problems and capacity shortage. For most cases, it is recommended to invest for the improvement of facilities at military aerodrome, especially the terminal building to accommodate more commercial activities, instead of constructing a new civil airport.

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# **Pilot and Air Traffic Controller Relationships : The Role of Interdependence and Relative Influence**

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There have been many studies which revealed most of the accidents related to pilot errors. Looking at each phase of flights, the accidents which occurred at the segments of take-off and landing consist of 70%, because these phases need precise cooperations between pilots and ATC specialists to make sure every instructions understood and instruments to be normal. Therefore, the accidents of these phases leave great regrets and the price was enormous to people and equipments. Until now, most of the studies investigate the accident itself and very few show the relationships between pilots and air traffic controllers. This study analyzes the impacts of inter-dependence to mutual trust, cooperations and relationship efficiency between them who play important parts in flight. Based upon the findings, the inter-dependence has an effect on mutual trust and the latter influences to cooperations. Also, mutual trust and cooperations have a leading role in the relationship efficiency. It implies that mutual trust, cooperations, and the degree of inter-dependence are important factors to improve the relationships between them.

## **INTRODUCTION**

Pilot and Air traffic controller are effort developed to succeed in flight environments such as



in the aviation safety and air transportation. Our proposed model, using data from Pilot and ATC, substantiates that interdependence and relative influence between the (pilot and ATC) partners impact relationship effectiveness through mutual trust and cooperation as co-workers. Drawing on the theoretical perspectives of organizational and social exchange theories, our study develops and tests a model of partner relationship effectiveness that incorporates the effects of the interdependence and the relative influence of the partners as co-workers by mutual trust and cooperation.

Analysis of interaction levels, integrates trust-based (Morgan and Hunt 1994) and interdependence/influence-based (Kumar, Scheer, and Steenkamp 1995) models of relationship effectiveness, explicitly recognizes the conceptual difference between interdependence and relative influence, examines interdependence, trust, cooperation, and relationship effectiveness.

And Studies (Moorxnan, Deshpand and Zaltman 1993; Anderson and Narus 1990) have generally examined these constructs at the individual level of analysis and taps into the perspectives of both partners in a relationship.

After reviewing the background and theoretical foundation for this study, our model is developed, the research approach is described, the results are shared and analysed, and the implications for managements and future research are based.

## **Background for the research**

### **Interdependence**

Interdependence is generally defined in terms of the structure of dependence relations the extent to which firms need to maintain a relationship with a partner in order to achieve their goals (Anderson and Narus 1990; Frazier 1983) and reflects both the magnitude and symmetry of dependence (Gundlach and Cadotte 1994; Kumar, Scheer, and Steenkamp 1995).

On the other hand, power/influence is the ability to affect another's decision making (Wilkinson 1974) or evoke a change in another's behavior (Gaski 1984). Interdependence is the extent to which both partners perceive a need for their relationship. This conceptualization is rooted in Thompson's (1967) concept of task interdependence and is concerned with the extent partners rely on each other to realize joint opportunities. It is consistent with Anderson and Narus's (1990) notion of relative dependence, in that interdependence is a relational construct that reflects the interaction of individual perceptions of dependence.

Empirical support for a linkage between interdependence and mutual trust is limited as many

researchers have implicitly assumed that dependence relations are characterized by trusting relations (Andaleeb 1996). Andaleeb(1996) and Geyskensetal(1996) found interaction effects between trust and dependence and trust and interdependence asymmetry, respectively.

### **Mutual Trust**

For stable ongoing relationships, trust must be mutual(Anderson and Weitz 1989) as unreciprocated trust by one party will lead to a withdrawal of trusting behavior and a subsequent downward spiral of mistrust(Homans 1961). Consequently, the research model incorporates mutual trust, the extent to which both partners trust each other, or the extent of mutual trust perceived in the relationship as a whole.

Integrating the works of Swan, Trawick, and Silva(1985) and Gabarro (1978), we conceptualize mutual trust as having facets of : honesty/integrity, reliability/dependability, responsibility, competence, likeability, judgment, and motives/intentions.

The centrality of trust in facilitating effective interorganizational and interpersonal relationships well established theoretically(Ring and Vane Ven 1992 , 1994; Morgan and Hunt 1994).

From a social exchange theory perspective, mutual trust is essential for ongoing relationships since exchange entails unspecified obligations, and parties have no way to ensure appropriate reciprocation(Blau 1964). Some previous studies of trust and dependence have specified trust as having a moderating effect on the relationship between dependence(Andaleeb & Geyskensetal. 1996).

This approach is consistent with Morgan and Hunt ( 1994 ) in their context of relationship marketing. Consequently we rely on social exchange theory , the conceptual centrality of trust in relationship marketing , and limited evidence to hypothesize

**H1 : Greater interdependence between partners(pilot and air traffic controller) will lead to greater mutual trust in their working relationships.**

### **Cooperation**

Cooperation is the extent to which partners undertake voluntary coordinated action and jointly strive to achieve individual and mutual goals (Skinner, Gassenheimer, and Kelley 1992). Cooperation is aimed at both achieving these goals and at maintaining the longer-term

relationship. Interdependence is also expected to directly affect partner relationship effectiveness.

Thus there is theoretical and empirical support to hypothesize :

**H2 : Greater interdependence between partners(pilot and air traffic controller) will lead to greater cooperation in their working relationships.**

**H3 : Greater mutual trust between partners will lead to greater cooperation .**

### **Effectiveness of Relationships**

Following Gladstein(1984), effectiveness is conceptualized as a higher-order construct concerned with task performance, non-task performance, partner satisfaction, and customer satisfaction as perceived by partner sales representatives. Satisfaction is an overall measure of the extent to which the selling partner relationship meets the needs of the partners. Customer satisfaction is the partners' perceptions of the extent to which their customers have been pleased with their activity and performance. This relationship-level conceptualization of effectiveness is appropriate here given the focus on relational processes and outcomes.

By cooperating, partners voluntarily increase their vulnerability to each other.

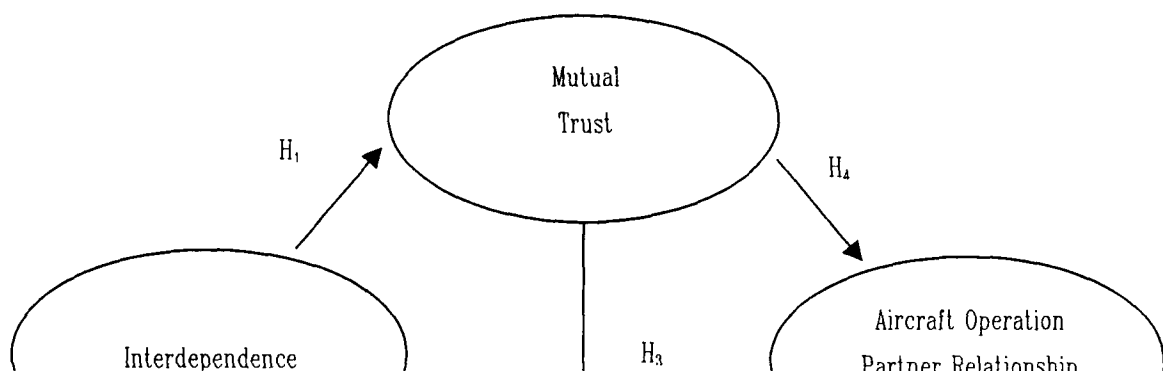
Relationships between trust and cooperation have been found in channel relationships(Morgan and Hunt 1994) and in buyer-seller relationships(Schurr and Ozanne 1985; Selnes 1998).

**H4 : Greater mutual trust between partners(pilot & air traffic controller) will lead to more effective working relationships .**

**H5 : Greater cooperation between partners(pilot & air traffic controller) will lead to more effective working relationships .**

<Figure 1>

A Model of Pilot and Air Traffic Controller Relationship Effectiveness



## **Research Method**

Survey research was used to collect data from pilots and air traffic controllers involved in aviation partner relationships in the air transportation industry. Two hundred sixty-eight participants (pilots 144, air traffic controllers 124) were randomly selected from the employee who work at air transportation industry in Korea. Participants were asked to consider a customer situation in the past where an aviation partner was involved. They were asked a self-defined successful relationship and a self-defined unsuccessful relationship. Participants then responded, mainly as key informants, to questions about their working relationship with that partner.

### ***Measures***

Modeled constructs (Figure 1) were operationalized with multiple indicators using a mix of original and adapted 5-point Likert scales. Both relationship-level items (informants reporting on relationship properties) and individual-level items (partner reports of their own beliefs [e.g., trust of their partner] aggregated to reflect a relationship property [e.g., mutual trust]) were used as measures. This is in the tradition of multimethods of measurement (Campbell and Fiske 1959). Individual-level items were aggregated to the relationship level by taking the square root of the product of the partner responses. This procedure captures both the level of an aggregated relationship property and the degree of differences in partner responses to individual-level items

(Smith, 1999).

*Interdependence* was measured by three items based on the conceptual work of Anderson and Narus(1990) and Sethuraman, Anderson, and Narus(1988). These original items tapped the extent to which both partners recognized they needed each other to accomplish their objectives and were dependent on each other to be successful.

*Mutual trust* was measured by six items reflecting the facets of trust identified by Swan, Trawick, and Silva(1985) and Gabarro(1978): honesty/integrity, reliability/dependability, responsibility, competence, likeability, and motives/intentions.

*Cooperation* was measured by three items conceptualized by Heide and Miner (1992): flexibility, information exchange, joint problem solving.

*Effectiveness* was measured by four relationship-level indicators closely adapted from Gladstein's(1984) measure of effectiveness in a team selling context. These items tapped mutual satisfaction, perceived customer satisfaction, partner perceptions of task performance, and manager perceptions of partnership task performance.

### ***Assessment of Construct Validity and Internal Consistency***

Prior to analyzing the data, the psychometric properties of each of the five measurement scales was assessed for construct validity(Peter 1979, 1981). A factor loading of .50 was used as a cut-off for factor selection, although all items exhibited factor scores of .53 and above. The summary statistics reported in <Table 1> reveal that a one-factor solution emerged for all four constructs. The analyses indicate that the measures seemingly demonstrate adequate construct validity.

To assess the internal consistency of the scale, Cronbach's coefficient alpha was computed(Cronbach 1951). As shown in <Table 1>, reliability estimates for five scales ranged from .62 to .83, thus exhibiting adequate reliability.

<Table 1>

Rotated component matrix & Reliability test

	Component				Cronbach's $\alpha$
	1	2	3	4	
Interdependence 1			.723		

Interdependence 2			.776		.6547
Interdependence 3			.681		
Mutual Trust 1	.665				.8202
Mutual Trust 2	.532				
Mutual Trust 3	.626				
Mutual Trust 4	.711				
Mutual Trust 5	.739				
Mutual Trust 6	.693				
Cooperation 1				.616	.6156
Cooperation 2				.805	
Cooperation 3				.677	
Effectiveness 1		.707			.8337
Effectiveness 2		.649			
Effectiveness 3		.825			
Effectiveness 4		.791			

### ***Model Specification and Testing***

The model was specified, and its parameters estimated, following the Maximum Likelihood Estimation(MLE) approach to structural equation modeling. The measurement model represents the epistemic relationships between the observed variables and the constructs. Using Cohen et al's (1990) guidance, these epistemic relationships were specified as reflective for all constructs suggesting that the constructs are manifest in or give rise to their measures. As per Anderson and Gerbing(1988), the measurement model was first assessed using confirmatory factor analysis(via LISREL), and then reliability and convergent, discriminant, and nomological validity were evaluated in the context of the theoretical model.

## **Analysis and Results**

### ***Preliminary Analysis***

Consistent with Anderson and Gerbing(1988), using LISREL and traditional tests of item and construct reliability, measurement properties were assessed and measures refined before structural analysis was conducted. Differences in perspectives between Sponsor and Partner representatives necessitated respecification of the model into two. But t-test of the two partner group didn't reveal significant difference in Interdependence, Effectiveness<Table 2>. So in this study we set up a one model.

<Table 2>

T-Test Results: Relationship of Pilots and ATC in Aircraft Operation

	Pilots (n=124) Mean(S.D)	Air Traffic Controllers (n=144) Mean(S.D)	t-value	p-value
Interdependence	3.82(.68)	4.06(.54)	-3.11	.00**
Mutual Trust	3.46(.54)	3.55(.59)	-1.23	.21
Cooperation	3.94(.53)	3.83(.58)	1.64	.10
Effectiveness	3.67(.60)	3.74(.57)	-1.01	.31

\*\* p < .01

### ***Structural Results***

We estimated the hypothesized structural model using LISREL8.0. The fit of model was acceptable(Chi-square = 226.878, p = 0.00, GFI = 0.902, CFI = 0.908).

<Table 3>

Standardized Parameter Estimates, T-values, and Summary of Results

Structural Path	Standardized Coefficient	t-value	Hypothesis
Interdependence -> Mutual Trust	0.582	5.318**	H <sub>1</sub>

Interdependence -> Cooperation	0.055	0.500	H <sub>2</sub>
Mutual Trust -> Cooperation	0.604	5.446**	H <sub>3</sub>
Mutual Trust -> Partner Relationship Effectiveness	0.446	3.694**	H <sub>4</sub>
Cooperation -> Partner Relationship Effectiveness	0.474	3.281**	H <sub>5</sub>
<p>Chi-square with 99degrees of freedom = 226.878(p = 0.00)</p> <p>Goodness of fit(GFI) = 0.902</p> <p>Adjusted goodness of fit(AGFI) = 0.866</p> <p>Root mean square residual(RMR) = 0.060</p> <p>Comparative fit index(CFI) = 0.908</p>			

\*\* P < 0.01

As to H<sub>1</sub>, there are strong direct effects linking Interdependence and Mutual Trust in model. This finding is consistent with that of Kumar, Scheer, and Steenkamp (1995) and suggests that interdependence provides an important foundation for the development of trust in selling partner relationships. It is the perceived need by both partners for each other and the relationship that enables them to take risks, which when reciprocated, forms the bonds of trust.

Interdependence was not found to be a predictor of Cooperation (H<sub>2</sub>) in model. In support of hypothesis H<sub>3</sub>, Mutual Trust was found to be a strong predictor of Cooperation in model. This is consistent with Morgan and Hunt's (1994) findings and suggests that selling partners are unlikely to risk established accounts or engage in new opportunities without a foundation of trust. Mutual Trust was found to be the second most important predictor of relationship Effectiveness (H<sub>4</sub>) in model. This is consistent with the centrality of trust in theories of relationship marketing (e.g., Morgan and Hunt 1994) and with Ring and Van de Ven's (1994) observation that trust may be particularly important in non-equity alliances. Cooperation was found to be an important predictor of Effectiveness (H<sub>5</sub>) in model. This result is consistent with Cespedes' (1992) finding of the importance of coordinated action in team selling and reinforces that selling partners need to work together as true partners to be effective.

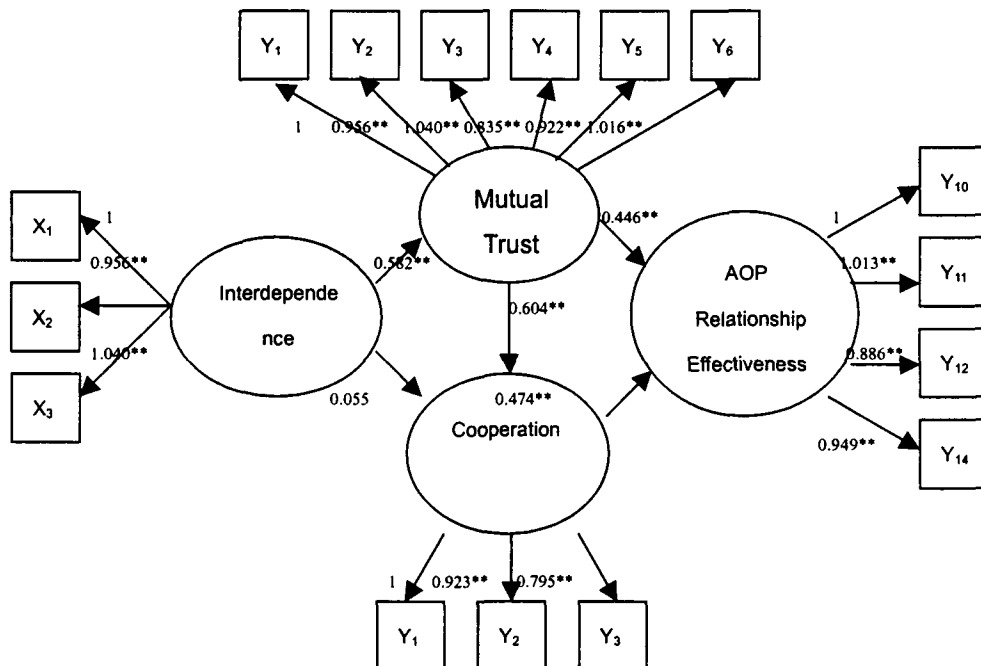
These results further support relationship marketing theory that suggests balanced



relationships are more stable and achieve greater non-performance and performance outcomes than relationships where one party has greater power or influence (e.g., Anderson and Weitz 1989; Dwyer, Schurr, and Oh 1987).

<Figure 2>

A Model of Pilot and ATC Relationship Effectiveness Structural Results.



\*\* p < .01

### Implications

Our results suggest that interdependence should be as central a construct as trust in relationship marketing research. Mutual trust and cooperation were both found to be key predictors of relationship effectiveness. And mutual trust was found to be key predictors of cooperation

The centrality of interdependence suggests that it is imperative that aircraft operation partners

perceive a need for each other. They can enhance their partnership value by developing and demonstrating each experiences, and by providing access to resources, such as technical support or administrative assistance. Making one's value or potential contribution known to prospective partners is also important and might be accomplished through role plays or partner referrals.

Mutual trust is what allows aircraft operation partner relationships to develop and grow from opportunity to opportunity. While trust clearly takes time to develop, aircraft operation managers can facilitate the process by instigating joint training sessions where partners can demonstrate their trustworthiness, e.g., in role-play situations.

Cooperation is also critical for effective aircraft operation partner relationships. Adaptation to organizational rules and procedures and partner styles and preferences may be required, and give and take is needed. Managerial intervention to bridge organizational differences may be required to permit aircraft operation partners to cooperate.

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# **Liberalization of Air Cargo Services: Background and an Economic Analysis**

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**Abstract:** This paper provides a background discussion and economic analysis on the liberalization of air cargo services in international aviation. It shows that all-cargo carriers may have different routing needs than passenger carriers and thus require different sets of air traffic rights from those needed by passenger carriers. On the other hand, separation of air cargo and passenger rights will be fraught with difficulty in Asia because of distinctive characteristics of its air cargo market, where most passenger carriers have substantial cargo business and operate "combination" fleets.

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## 1. Introduction

The liberalization of international air transport services has been the subject of numerous papers. Most of the studies have focused on the air passenger market. However, there have been growing interests in the subject of liberalization of air cargo services for the last few years. The interests arise due in part to the fast growth of the sector, and in part to the push by shippers and traders and by major freighter carriers especially air express operators. For the last decade or so, streamlining business supply chains has made air cargo in general, and air express in particular, the fastest-growth area in the dynamic cargo sector. Companies need to reduce inventories and cut down the time it takes to move products to the market. Product life spans are also shortening in many industries (computers, pharmaceuticals, and designer clothes). While some companies have turned to “virtual warehousing,” keeping goods in transit as a substitute for holding goods in storage, a growing community of E-commerce retailers have begun to rely on strategically located “fulfilment centers” to enable speedy and economical delivery of goods bought “on-line.” Moreover, as a result of continuous declines in tariffs and other trade barriers, *international fragmentation*, i.e., outsourcing various production blocks to countries that possess a comparative advantage in that type of productive activity becomes a major economic force to firms to remain competitive. This increases the demand for international service links, in the form of transport services, and intensifies the search for a more efficient trade regime in international air cargo services.

Despite its growing importance, there are few published papers that examine effects of liberalization in international air cargo services. In this paper we provide a general discussion of various issues related to the liberalization of air cargo services in international aviation. The paper is organized as follows. Section 2 describes some basic characteristics of air cargo service, and Section 3 discusses general background of approaches to liberalization. Section 4 examines features of air cargo service that distinguish cargo from air passenger services and the implications for air cargo liberalization. Section 5 examines the interaction between air cargo and passenger services and the pattern of cargo vs. passenger services for both US and Asian airlines, and then discusses their implications for liberalization of the international air cargo industry. Section 7 contains concluding remarks.

## **2. Basic Characteristics of Air Cargo Service and its Growth**

### **2.1. Air Cargo vs. Land and Sea Cargo**

For cargo, it is much more expensive to use air transportation than surface transportation (road, sea, and rail). There are two principal reasons for a shipper to select the air mode. First, the speed of air transportation, especially over long distances, is critical for goods subject to spoilage, goods requiring next-morning delivery (e.g. newspapers), and a key competitive advantage for goods subject to just-in-time supply chain pressures, in particular computer-related products and fashion goods. Second, air transportation's low risk of losing or damaging shipments is an advantage for goods with a high ratio of value to size. Air cargo charges for these valuable and time-sensitive goods are usually small in comparison with the value of the items.

The viability of air cargo transportation for shippers can be further assessed using the total distribution cost (TDC) framework. Applying this framework to distribution involving long-distance transportation, it is argued that the use of slower modes (such as land or sea transportation) may lead to higher total distribution costs than the air mode even though the latter may involve significantly higher freight charges. Striking a minimum TDC involves a trade-off between freight costs on the one hand, and inventory cycle and warehousing costs on the other. If inventory costs are very high relative to freight costs, air transportation becomes an attractive option while land or sea transportation is preferred in the reverse scenario.

The TDC framework becomes particularly relevant when the cargo industry is viewed in the context of providing broader business-related logistics services. With shifting economic patterns, companies are now manufacturing the parts of goods in different locations before reaching their final destination. With this dispersal of production and services and the fast flow of information, product life spans are shortening in many industries. Companies have, therefore, turned to "virtual warehousing," relying on goods in transit as a substitute for holding goods in storage. This helps reduce the risk of obsolescence and is especially crucial for those industries dealing with computers, medical equipment, pharmaceuticals, perishables and designer clothes.

Today, international airfreight traffic constitutes less than 2% of all tonnage transported on an inter-continental basis, with ships carrying the rest. Goods carried by air represent over a third of the total value of international trade, however. For many countries, this percentage is considerably higher, and most economies involved in international trade are seeing a steady increase in the percentage of goods moving by air, based on their total value of export and import.

## **2.2. General Air Cargo vs. Express Cargo**

Within the air cargo sector, there have historically been two major cargo types, namely, express cargo and general (heavy lift) cargo. The latter is still in the dominant position: for example, it accounts for around 95% by weight and 85% by value of airfreight handled by Hong Kong. Worldwide the market share of express cargo was by value 9.2% in 1999. However, the past two decades have witnessed a much faster growth in air express than in overall air cargo business. In 1979, just-in-time (JIT) was introduced to American business (Vokurka and Davis, 1996). JIT can be broadly defined as a logistics system philosophy for providing better customer service at lower total cost. Lower inventory is considered to be the primary purpose of JIT logistics. As such, it implies greater use of air cargo transportation. To see this, consider various types of inventory. In-transit (or, pipeline stock) inventory is a function of transit time. Since air is the fastest mode for many types of goods, airfreight yields lower pipeline stock. At the destination, the two primary types of inventory are cycle stock and safety stock. Cycle stock is a function of incoming shipment size. Air cargo shipping allows for more frequent delivery of smaller shipments and lower cycle stock. Finally, safety stock is a function of lead time and lead time variability. By offering transit time speed and reliability, air cargo also reduces safety stock (Larson, 1998).

Furthermore, within the air cargo sector, practice of JIT logistics in certain manufacturing sectors – in particular the electronics and computing businesses - has led many corporations to favour air express. Such companies, faced with the need to reduce inventories and cut down the time it takes to move a product to the market, have found it worthwhile to pay a premium for one-day or



two-day time-definite delivery. Product life spans are also shortening in many industries, in particular, computers, pharmaceuticals, and designer clothes. Companies, therefore, have turned to “virtual warehousing,” keeping goods in transit as a substitute for holding goods in storage.

### **2.3. Integrators and Industrial Structure**

As a consequence, the integrators, i.e., air express companies that provide an inclusive door-to-door service, have developed and expanded quickly over the last two decades. Nowadays, the four largest integrators, namely, Federal Express (FedEx), UPS, DHL and TNT, account for about 90% of the world’s air express, door-to-door market. Of the four integrators, FedEx and UPS operate their own air flights, while DHL and TNT make more use of the services of major airlines. It is worth noting that the high value-added integrators were less affected by the recent Asian financial crisis. DHL, for instance, registered a 15% growth from Asia to the US and 10% growth from Asia to Europe in 1998. While overall air cargo traffic through Hong Kong and Singapore fell in 1998, air express to/from Asian markets still rose 3.5%.<sup>1</sup>

However, it remains open to question how far across the manufacturing spectrum such acute just-in-time pressures will span. At the same time, competitive response by passenger airlines with substantial cargo businesses to provide time-definite and express delivery, and to exploit sea-air combinations, might create new business niches across the air cargo spectrum. As dedicated air express integrators continue to expand their businesses to accommodate general cargo and to persuade companies to “graduate” to higher value-adding air express services, so it is likely that those airlines dedicated to general cargo will also continue to expand their express services. In effect, a few combination carriers have attempted to compete head-on with these integrators by entering the air express, door-to-door market by forming partnerships with freighter and shipping companies. For example, Cathay Pacific has expanded its services into the express industry, mainly with its Wholesale Courier and Cargo Express services. Cathay Pacific has also entered into an innovative arrangement with DHL to provide overnight short-haul cargo services to Asian regional destinations, exploiting the new night-time capacity available at Hong Kong’s new

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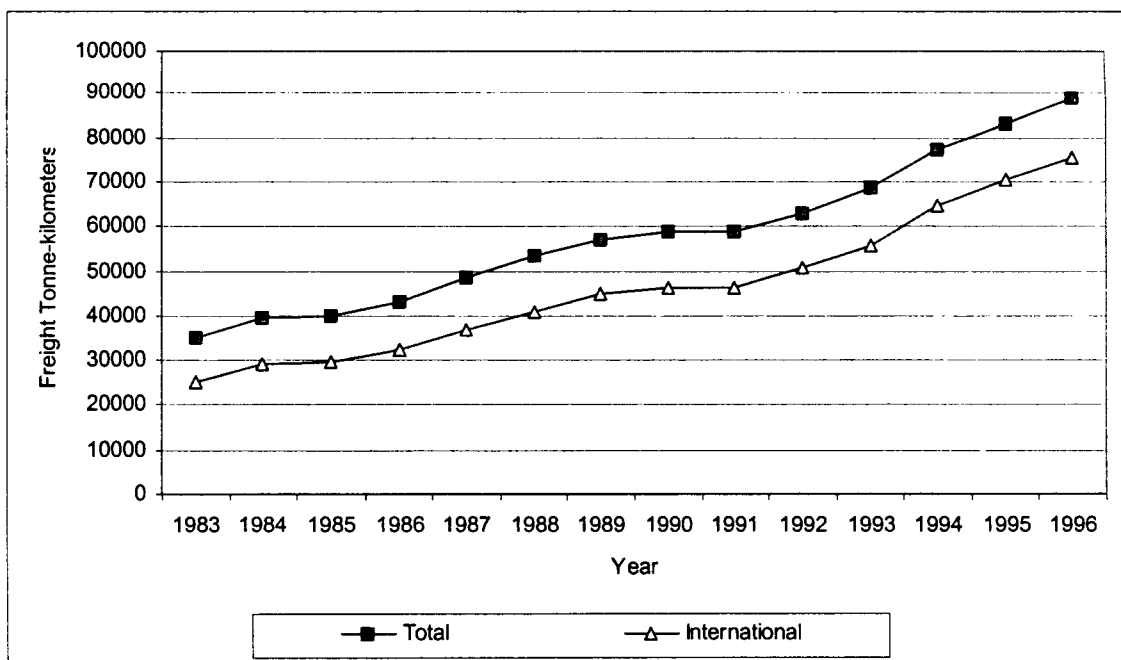
<sup>1</sup> In Hong Kong, express carriers with their own airside facilities also benefited opportunistically from the two-month disruption of general air cargo services following the opening of the new airport at Chek Lap Kok in 1998.

airport during a period when passenger aircraft would otherwise have been “parked” overnight (Dodwell and Zhang, 2000).

Another development that can impact this product/provider spectrum is the rapid growth of Internet applications. Overnight document delivery has been an especially fast-developing sector of the air express/integrator market. However, document business is expected to decline as paper data can be transmitted with increasing ease via Internet.

#### 2.4. Growth of International Air Cargo

**Figure 1. World Total Freight and International Freight by Air (millions)**



Source: World Air Transport Statistics.

The air cargo volume throughout the world has strongly linked to trade growth. In effect, it has grown slightly faster than the international trade volume; consequently, it has grown at between 1.5 and 2 times the rate of worldwide GDP growth. Average annual growth in freight-tonne kilometres on international scheduled services during the last decade is 7.9%, while on domestic services it is 2.1%. The situation is depicted in Figure 1. In addition, both the JIT pressures and the vertical integration of the logistics industry along with the increasing trend towards

outsourcing distribution have led to much faster growth in the air express market than the total air cargo market. Annual growth in international express has averaged nearly 24% since 1992. Finally, E-commerce is likely to generate increased demand for air cargo, particularly the time-definite, express market.

Future air cargo growth is expected to be robust. According to Boeing World Air Cargo Forecast 2000/01, world airborne cargo will grow by 6.4% per year for the next 20 years. Most of this growth will occur in international markets, which will exceed 86% of total revenue tonne-kilometers (RTK) by the year 2019. Two key factors are identified as drivers for the forecast: international express cargo, and E-commerce. The international express segment is expected to grow at an annual rate of 13% through 2019, which is twice the overall growth rate. Its market share is expected to grow from 9.2% in 1999 to 31% in 2019. The faster growth is due largely to its time-definite nature and the global trend in outsourcing logistics. As for E-commerce, it is expected that the increase in international and inter-continental transactions in both B2B and B2C markets will contribute to air cargo growth in excess of general economic expansion.

### **3. Approaches to Liberalization**

In November 1979, amendments to the Federal Aviation Act deregulated domestic all-cargo air service in the United States, removing government control over rates and routes. Limits on aircraft size were also eliminated. Deregulation was promoted on the promise of lower rates and improved services to shippers. It is found that the deregulation, along with the use of JIT, has stimulated the air cargo growth in the US (e.g., Larson, 1998).

On the other hand, all commercial aspects of international air transportation have been governed by bilateral air services agreements (ASAs) since the Chicago Convention held in 1944. ASAs are based on the principle of reciprocity, that is, an equal and fair exchange of rights between countries with different market size, different geographical location and different economic interests, and with airlines of different strength. They fix a set of rules to identify the airlines of the contracting parties with the rights to fly on each route, determine the capacity that can be

provided by each of those designated airlines, and limit the capacity that can be offered by airlines from third countries.

In discussing the exchange of rights for scheduled air services between nations, a vocabulary has emerged that is referred to as the freedoms of the air.<sup>2</sup> The first two freedoms are considered as “transit” rights as opposed to the remaining freedoms, which are counted as “traffic” rights. The third (fourth) freedom refers to the right of an airline to carry traffic from the home (foreign) country to the foreign (home) country. Perhaps the most controversial are the fifth and seventh freedoms. The fifth freedom is the right of an airline to pick up additional traffic in a first foreign country and carry it to a second foreign country. Typically it is an extension of flights that start out as third or fourth freedom rights. On the other hand, the seventh freedom is the right of an airline to pick up traffic in one foreign country and carry it to another foreign country, without the flight originating from or ending at the home country; consequently, this is a pure foreign flight. Both fifth and seventh freedom rights are limited in practice. Finally, cabotage, the right to provide air services within a foreign country, is almost non-existent at present.

### **3.1. The US Bilateral “Open Skies” Initiative**

Thus, bilateral ASAs have a large impact on the aviation industry because, unlike shipping, airlines require rights to fly passengers or cargo to/from other countries. Restrictions are often imposed on the ability for a carrier to operate services to destinations where there is a perceived business opportunity. The bilateral system is under increasing pressures to keep pace with the general economic and trade expansion of the world (e.g., Findlay, 1999).

Since 1992, the US has been promoting bilateral “open skies” agreements with individual nations in Europe in preference to a multilateral approach. The first open-skies deal was signed in September 1992 between the US and the Netherlands. By the end of 1996, the US had successfully signed open-skies deals with ten European countries. Difficult US-UK negotiations

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<sup>2</sup> There are nine concepts of freedoms of the air. The first five freedoms are specified in the Chicago Convention while the others have been developed subsequently.

continue, while the US is also targeting France for a possible deal. The US signed an open-skies agreement with Canada in 1995.

The US government has been pursuing similar strategies towards Asian countries. The primary reason for this US strategy is to optimise its bilateral negotiating leverage to ensure that US carriers continue to play leading roles in the world air transport industry (Oum, 1998). The US open-skies initiative in Asia was announced in summer 1996. By January 1997, Singapore became the first Asian country to sign an open-skies agreement. It is noted that recent bilateral agreements between the US and some Asia-Pacific economies (Taiwan, the Philippines, Brunei, and Singapore) include seventh-freedom traffic rights on cargo (i.e., the hubbing or change of gauge rights in a foreign territory), although limits are imposed on the fifth-freedom rights for passenger travel. The provision is intended to help Federal Express and UPS to set up mini-hubs in Asia (Oum, 1998). On May 1, 2001, the U.S. and four other Pacific-rim nations (Singapore, New Zealand, Chile and Brunei) signed the accord known as the "Multilateral Agreement on the Liberalization of International Air Transportation." The new element is the full liberalization of cargo operations among the five countries. It is now possible for Singapore Airlines, for example, to operate cargo services between the US and New Zealand without go via Singapore.

The US initiative has met strong resistance in Japan. In March 1998, the US and Japan agreed a new Memorandum of Understanding (MOU). Since the Japanese government strongly resisted, the MOU was not the liberal agreement that the US wished to get. The official reason for Japan's position was that there remained an inequality of rights and interests in the Japan-US bilateral agreement, and this inequality hampered fair competition in air transport market between the two countries.<sup>3</sup> The US is also pushing hard to have the hubbing rights in Hong Kong, although the US-Hong Kong bilateral has already been very liberal.

A consequence of the US initiative is that if the US liberal bilateral initiative succeeds in having sufficient Asian countries offer fifth or seventh freedoms to the US, then the US carriers may be

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<sup>3</sup> The Japanese government insisted that, first, in the original agreement the US has unlimited fifth freedom rights beyond Japan, while Japan has only one point of such right beyond the US. Second, the US has more "full right" carriers, carriers that can change capacity without advance notice, than Japan. Third, there is an imbalance in the

able to serve intra-Asia spokes more freely than the home carriers of the spokes, in particular if the two countries concerned have restrictive bilaterals between themselves. The strategy by the US is sometimes referred to as a strategy of “divide and conquer” (Oum, 1998; Findlay, 1999).

### 3.2. The Multilateral Approach

An alternative approach is to adopt a multilateral approach to air transport liberalisation. The Uruguay Round succeeded in applying multilateral trade concepts to three limited aspects of the air transport sector, in the form of a separate *Annex on Air Transport Services* under the GATS:<sup>4</sup> aircraft repair and maintenance; selling and marketing of air transport services; and computer reservation system (CRS) services. The Annex specifically excluded anything affecting traffic rights and services directly related to their exercise.<sup>5</sup>

The two most important principles of the GATS are the most-favored-nation (MFN) clause and national treatment. The (unconditional) MFN clause means that the concession that one country yields to another country extends automatically to all other WTO member economies. In the case of air services, a distinction was drawn in the Uruguay Round between the application of MFN to traffic rights – routes, capacity, and pricing – and its application in the three ancillary areas (i.e., aircraft repair and maintenance, selling and marketing of air transport services, and CRS services). On balance, it is not yet clear that liberalization in the air transport sector would be speeded up by the application of (unconditional) MFN to traffic rights (Kasper and Hindley, 1999).

Application of the national treatment principle to the air services sector would require that foreign services and suppliers be treated the same as comparable home services and suppliers. Applying this principle to non-traffic rights would be relatively straightforward – as illustrated by

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capacity provisions in the North Pacific market. The MOU has equalized the number of full-right carriers for the two countries, however. See Yamauchi (1999).

<sup>4</sup> A fourth, Ground Handling Services, was considered until late in the Uruguay Round but eventually discarded.

<sup>5</sup> Traffic rights were defined in the widest sense to include routes, capacity, pricing and the criteria for the designation of airlines. Specifically, paragraph 6(d) of the Annex states: “*traffic rights* mean the right for scheduled and non-scheduled services to operate and/or carry passengers, cargo and mail for remuneration or hire from, to, within, or over the territory of a member, including points to be served, routes to be operated, types of traffic to be

the coverage of three ancillary services in the Uruguay Round. If applied to traffic rights such as routes, national treatment becomes more problematic (Kasper and Hindley, 1999).

Recognising these potential problems with the multilateral mechanism, the approach also offers some obvious advantages for the integrated express air cargo sector. First, it provides an opportunity to include aviation in the negotiations for the broader goods and services. This may result in a win-win situation for all the countries involved. Second, if the integrated express air cargo industry is under the GATS umbrella, then several issues of key importance to the carriers can be addressed relatively easily. For example, customs clearance procedures for transshipments can be dealt with under the WTO trade facilitation programme, whereas restrictions on inter-modal and airport handling rights fall under the market access programme. Finally, this may be a more strategic and effective way to deal with the US “divide and conquer” strategy.

### **3.3. “Open Skies” for Air Cargo First**

The approach of the “GATS 2000” negotiations once again raises the issue of how – and to what extent – the airline sector should be dealt with in the WTO.<sup>6</sup> Various possibilities to expand the scope of the services in the Annex have been advanced by governments, international organizations and by various trade associations in the last year or so. One prominent proposal is to include some services involving traffic rights, specifically all-cargo services and express delivery services, under the Annex of the GATS.

Since substantial liberalization in the air passenger sector is not likely to occur in the near future, the debate on this proposal centers on whether the air cargo rights should be separated from the air passenger rights and be liberalized first through the multilateral services liberalization program of the GATS. It appears that some of the US carriers are for the proposal while most of the Asian carriers are against it. As to be illustrated below, the heavy reliance of Asian carriers on air cargo carriage as part of their overall business model means that it is unlikely that air cargo in

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carried, capacity to be provided, tariffs to be charged and their conditions, and criteria for designation of airlines, including such criteria as number, ownership and control.”

<sup>6</sup> “GATS 2000” refers to the new round of multilateral negotiations on services trade under the GATS, mandated to start in 2000.

Asia will develop along the lines of the US market where the air cargo market is dominated by all-freighter carriers including dedicated express carriers. As a consequence, liberalizing the air cargo sector first may result in differential impacts on the US and Asian carriers, and separation of air cargo and passenger rights may be fraught with difficulty because of the distinctive inter-linkage of passenger and air cargo business in Asia. In effect, for this reason IATA, an inter-airline or trade association that represents the interests of airlines, is still yet to develop an industry view on the proposal.

## **4. Distinct Features of Air Cargo and Passenger Services**

### **4.1. Needs of Air Cargo vs. Needs of Passengers**

Human air travellers prefer to fly non-stop, directly to their destination, wherever possible. If a transfer is needed, they prefer the waiting time at the hub airport to be as short as possible (see, e.g., Carlton, Landes and Posner, 1980). They also prefer an attractive airport environment, rich in diversions, or endowed with facilities to enable them to work fluently, to make the waiting time as productive and enjoyable as possible. Cargo is relatively indifferent to such preferences. Whether it travels direct, or hubs through one or more airports, is of lesser consequence than for passengers. It is also insensitive to transfer flight synchronization, and to airport terminal services. By contrast, it is sensitive to different factors, including whether a change of aircraft is required, whether pallets need to be broken down and rebuilt, and the cost of trans-shipment handling.

In addition, cargo flows are unbalanced, or “uni-directional” – much more flows from Asia to the US than from the US to Asia, for example. By contrast, passenger air travel is much more balanced: passengers tend to make a two-way journey (from home to destination and back again). As a result, all-cargo carriers sometimes design their networks with “big circle” routes, while passenger carriers tend to fly east and west or north and south along the same linear route linking two cities.



As a result of these differences, all-cargo carriers sometimes have different routing needs and priorities than passenger carriers. It is for this reason (among others) that all-cargo carriers argue that separate all-cargo air traffic rights need to be negotiated, quite distinct from the air traffic rights negotiated in bilateral air services agreements on behalf of passenger carriers. Because of the bi-directional nature of passenger traffic, for example, it is more natural for countries to negotiate passenger traffic rights on a reciprocal basis than to negotiate cargo rights.

#### 4.2. The Inbound/Outbound Imbalance

As mentioned above, a consignment of cargo tends to move in a single direction. Cargo also tends to move from manufacturing to distribution centers, or from production to consumption centers, while passengers tend to travel to and from centres of commerce, production, and leisure. This difference suggests that passenger carriers filling belly space with cargo, and combination aircraft may not provide optimally efficient services both to passengers and cargo, and that an imbalance of inbound/outbound cargo can be significant on many given routes. Besides the apparent bilateral imbalance of cargo flows between Asia and North America, there are imbalances even within the same region. Table 1 shows, for example, there are imbalances of import/export cargo throughout the Asia-Pacific region. Moreover, such imbalances can be endemic. This is because fundamentally the inbound/outbound imbalance is influenced by import/export imbalances between countries/regions. Although solutions may exist to positively adjust import/export imbalances, the application of these solutions in any particular region will of necessity be subject to political, economic, commercial aspirations and development strategies. It also takes time to formulate and implement corrective policies.

**Table 1. Import/Export Airfreight Movements to Year 2000 (ton): Asia-Pacific**

	South Asia	Southeast Asia	Northeast Asia
South Asia - Imports from	37,700	62,500	47,000
South Asia - Exports to	37,700	80,500	55,500
Southeast Asia - Imports from	80,500	570,500	666,000
Southeast Asia - Exports to	62,500	570,500	1,001,800
Northeast Asia - Imports from	55,500	1,001,800	2,019,700
Northeast Asia - Exports to	47,000	666,000	2,019,700

Source: IATA's 1995 Airfreight Forecast (adapted from TLIAP, 2000).

Further, cargo and passengers may demand different scheduling and routing. Much express cargo seeks to move overnight, with departures in the late evening hours and arrival in the early morning hours, whereas passengers prefer to travel in the morning and early evening. (Overnight operation will also reduce the lead-time of cargo on the ground.) Cargo has less preference as to circuitry or number of stops, whereas passengers strongly prefer non-stop flights. Given the large quantum of belly space available on passenger routes, pure cargo operators tend to focus their attention on those major routes where there is particularly heavy demand for cargo space.

Cargo carriers also face their own scheduling difficulties because of the directional imbalance of air cargo. Air freighters may be fully laden when travelling eastbound from Asia to the US, or westbound to Europe, but then fly back to Asia with much lighter cargo loads. As a result of these supply/demand imbalances, air cargo rates vary greatly according to the time of year and the direction of travel. Sometimes, dedicated freighter operators construct special routing patterns – for example clockwise circular routes around the Pacific, or intensive “hub and spoke” operations. This can mean that they require different sets of air traffic rights from those needed or prioritised by passenger carriers.

#### **4.3. Network Patterns**

As indicated above, air cargo is concentrated on several key trade flows between regional centers of production and consumption. This concentration is more pronounced in cargo than for passenger flows (which are much more diffuse). This feature has contributed to the dramatic growth of hub-and-spoke systems for passenger travel after airline deregulation in the US. The hub-and-spoke operation is now emerging in the international market following global strategic airline alliances (see, e.g., Oum, Park and Zhang, 2000).

The ability to funnel traffic to one location (and changing aircraft) does not always work for air cargo. Air cargo traffic is predominantly focused only on a few flows that are based around centers of production and consumption. These flows are best met by substantial capacity on direct flights. The key determinant for air cargo volumes for most airports is the size and scope of local O&D market whether for exports or imports. For example, electronics and computers

produced for the US market should take the most direct route. Sending air cargo flows on indirect paths via hubs is time-consuming and inefficient.

On the other hand, hub-and-spoke systems work for smaller flows that are diffuse in nature and uneconomic to fly directly. This market is being catered for through the growth of express operations that specialize in these flows along with door-to-door distribution. Therefore, hubbing does make sense to express operators who handle smaller, diffuse flows. However, even for express operators, developing cargo hub-and-spoke operations needs to take into account the size and scope of the local O&D market. Hubs work best when there is a large O&D market or easy surface access to it. Without large O&D markets, even express operators have trouble making their operations operate profitably. As a result, dedicated all-cargo carriers prefer to gather cargo in particular hubs (where a large O&D market exists) to make best use of their fleet capacity, and then fly to a destination hub for break-down and onward carriage. They use regional hubs where shipments are processed centrally before onward distribution in order to profitably handle smaller flows within a guaranteed timeframe.

## **5. Interactions: All-cargo vs. Passenger Carriers**

### **5.1. Role of Passenger Travel as a Driver for Air Cargo Business**

The air transport industry can be divided into the cargo and passenger sectors. Cargo may be carried in the belly compartment of a passenger aircraft or in a freighter aircraft configured exclusively for that use. "Combi" aircraft are also used in which passengers may occupy the front section of the aircraft, with cargo occupying the back section. In Hong Kong, for example, between 55-60% of airfreight are carried in the belly compartment of passenger aircraft, so the two sectors overlap in a significant way.

For mixed passenger/cargo carriers, passenger revenue for most airlines is still significantly larger than cargo revenue. This can be seen from Table 2 where passenger revenue accounts for 70% or more for most airlines. But strategies that work for the passenger business may not be conducive for the cargo business. As an illustration, strategic alliances have generally worked

well for the passenger market, but they appear to have little bearing on air cargo. Passenger airline alliances are particularly more effective if they are formed on a regional or global scale rather than for specific markets. The former is referred to as major (“strategic”) alliances, whereas the latter as minor (“tactical”) alliances. Major alliances refer to network-based, strategic alliances in which partner airlines combine their networks to gain access to other parts of the global markets, whereas minor alliances refer to route-based alliances in which airlines cooperate on one or more routes without linking their entire networks. The prominent examples of major alliances include the Star Alliance, Oneworld, Air France/Delta, Wings, and Qualiflyer. Together these five alliances account for about 60% of the world air passenger market. It is found that the major alliances tend to increase partner airlines’ productivity and profitability, while the latter have no statistically significant impact on productivity and profitability (Oum, Park and Zhang, 2000).

**Table 2. Cargo Share of Revenue for Top 25 Cargo Airlines**

	US Carriers	Cargo share of revenue	Asian Carriers	Cargo share of revenue
“Combi” Airlines	United	5.2%	Korean Air	27.2%
	American	4%	Singapore Airlines	23.0%
	Northwest	7%	Japan Airlines	13.4%
	Delta	4%	Cathay Pacific	26.4%
	Continental	3.5%	China Airlines	33.7%
			EVA	39.6%
			Asiana	24.9%
			Thai Airways	16.5%
Cargo Airlines	FedEx	100%	Nippon Cargo	96.3%
	UPS	100%		
	Airborne Express	53%		

Source: *Airline Business* (November, 1999).

In contrast, air cargo alliances are more likely to occur for specific markets rather than on a regional or global scale. For example, the long-term limited alliance between Cathay Pacific and Lufthansa on the Hong Kong-Frankfurt route even though they are in different passenger alliance (Cathay Pacific in Oneworld and Lufthansa in the Star Alliance). Therefore, while strategic airline alliances work well in regards to passengers, they can be counterproductive for air cargo.

## 5.2. Different Patterns of Air Cargo Development: The US vs. Asia

In Asia, passenger airlines have competed keenly for general air cargo business, as can be seen from Table 3 that lists the top 25 cargo airlines in the world based on revenue ton kilometres (RTK). Express carriers have yet to build a similar dominating position in the general air cargo business. The proportion of cargo that requires time-definite delivery within 24 or 36 hours door-to-door is comparatively small in Asia (about 5% of all air cargo). However, there are indications on the part of both FedEx and UPS, which operate dedicated air freighter fleets around the Pacific region, that they would be keen to build general cargo businesses, in part to help ensure their aircraft fly as fully-utilised as possible. This trend is inevitably destined to intensify competition between mixed passenger/cargo carriers, conventional heavy-lift cargo carriers, and the express cargo operators.

A different pattern of development has occurred in the world's largest air cargo market, the United States. Here, the fact that most passenger carriers use narrow-bodied aircraft for their domestic operations has put severe limitations on their capacity to carry cargo. Passenger carriers also had a reputation for inefficiency and unreliability, as did the US Postal Service. As a result, dedicated air express carriers have emerged, using a combination of wide- and narrow-bodied aircraft, over 20 years raising their share of cargo carried from 4% to 60%.

While there is good reason to believe that air cargo operators and express carriers will continue to grow strongly in Asia, there is also good reason to believe that growth will not follow a pattern identical to that in the US, in particular the share "captured" from general air cargo carriers by dedicated express carriers. Most of Asia's domestic carriers operate wide-bodied fleets, and rely heavily on revenues from air cargo operations for their overall business profitability (see Table 2). It is therefore likely that they would have a keen competitive interest in building air cargo business in the coming decades, competing head-on with express carriers, and continuing to develop mid-price options like time-specific two and three day services as well as premium 24-hour express services.

**Table 3. The World's Top 25 Cargo Airlines (in RTK)**

Rank	Airline	Country	Type*	RTK million
1	Fedex	USA	I	9,988
2	Lufthansa Cargo	Germany	C	5,696
3	UPS	USA	I	5,575
4	Korean	South Korea	C	5,225
5	Singapore	Singapore	C	4,919
6	United	USA	C	4,767
7	Air France	France	C	4,595
8	British Airways	UK	C	4,277
9	Japan Airlines	Japan	C	4,088
10	KLM	Netherlands	C	3,885
11	Cathay Pacific	Hong Kong	C	3,297
12	American	USA	C	3,176
13	Northwest	USA	C	3,145
14	China Airlines	Taiwan	C	2,871
15	Delta	USA	C	2,764
16	Cargolux	Luxembourg	F	2,687
17	EVA	Taiwan	C	2,543
18	Swissair	Switzerland	C	2,518
19	Nippon Cargo/ANA	Japan	C	1,898
20	Martinair	Netherlands	C	1,817
21	Asiana	South Korea	C	1,788
22	Qantas	Australia	C	1,761
23	Airborne Express	USA	F	1,631
24	Thai Airways	Thailand	C	1,548
25	Continental	USA	C	1,533
World Total				120,000

\* C – Passenger and freight operator (“combination” carriers)  
 F – All freight operator, i.e., 100% cargo share of total RTKs  
 I – Integrated services operator

Source: *Airline Business* (November 1999). Year ended December 1998 or March 1999.

While many Asian airline groups have their own dedicated cargo fleets, many still rely heavily on their passenger route network to underpin the growth of their cargo services, and can be expected to retain that reliance into the future. Boeing, in its air cargo forecasts, predicts that express operators may account for 40% of global air cargo carriage in Asia by the year 2019. However, in view of the different pattern of aviation development in Asia, and the aggressive competitive interest in cargo on the part of those passenger airline groups that rely heavily on air cargo business, this may be a significant overestimate. As such, the development of passenger route networks is likely to remain closely linked with the development of cargo business.

### 5.3. “Open Skies” for Air Cargo?

For governments involved in negotiation of air services agreements, the key issue is likely to be that negotiation of passenger rights may not be easily separated from negotiation of cargo rights in those circumstances where carriers rely on cargo business for a substantial share of revenues. It is noteworthy that at a recent OECD workshop on reform of air cargo regulation in Paris, delegates expressed concern that "all-cargo and integrated services would be the only or major beneficiaries from any regulatory reform process, and "combi" aircraft (both belly cargo and main deck) would not benefit appropriately."<sup>7</sup> Putting on one side any arguments about the definition of "open skies," it is clear that this issue applies mainly to dedicated air cargo carriers: those carriers basing their air cargo businesses on the use of belly-space in passenger aircraft will rely for growth mainly upon the bilateral negotiation of air traffic rights for passenger aircraft.

In the United States, such segregation of the business interests of passenger and cargo carriers appears to have emerged naturally and reasonably from the fact that most domestic passenger air travel is in narrow bodied aircraft which have very limited cargo carrying capacity. Dedicated air cargo operators emerged, using a variety of pure freighter aircraft operating a dense domestic network based on selected hubs. Today air express carriers account for about 60% of all air cargo carried in the US.

The structure of passenger air travel across Asia is quite different from that in the domestic US market in many respects. Critically important, average journey lengths are longer, and many passenger carriers rely heavily on wide-bodied aircraft as they have developed route networks both domestically and internationally. These passenger carriers have therefore had a greater ability to carry large volumes of air cargo. Many have placed strategic emphasis on the growth of cargo business along their passenger route networks, and have come to generate a significant proportion of their total revenues from the carriage of cargo. It is therefore likely into the future that the Asia region's passenger carriers will continue to have substantial interest in the growth of their cargo businesses, not only acquiring dedicated cargo aircraft as part of their fleet, but

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<sup>7</sup> "Discussion summary" by the Transport Division of the OECD's Directorate for Science, Technology and Industry, July 12, 1999.

negotiating air services deals which allow them to use both passenger and pure freighter aircraft on many passenger routes.

If dedicated air express cargo services are likely to account for a smaller proportion of overall aviation activity in Asia, and since major international passenger carriers are going to retain a keen interest in developing both their cargo and passenger businesses – including both heavy-lift and air express services - it is reasonable to query whether a separate set of air services agreements for dedicated air cargo carriers is either desirable or achievable.

This is not to deny that the air express sector is likely to be one of the most dynamic areas of growth in the aviation industry in Asia in the coming decades. But the very fact that it is likely to be a highly dynamic sector, with passenger and cargo carriers alike anxious to build their cargo businesses as a critical area of business development, is likely to make it difficult to win agreement for air services agreements providing specific competitive benefits exclusively to cargo-only carriers.

It is thus important to recognise that airlines with strong revenue reliance on cargo (like China Airlines, Korean Airlines, Cathay Pacific, Asiana, China Eastern, Japan Airlines, Thai Airways and Lufthansa) will have quite different interests from those with only marginal reliance on air cargo (like United Airlines, Delta, American Airlines, Continental, Qantas and Northwest Orient (see Tables 2 and 3), and from dedicated all-cargo carriers. Again, this illustrates a clear division of strategic interest between airlines with a balanced reliance on both cargo and passengers (most Asian carriers), and those that either have minor air cargo interests, or rely wholly on air cargo for their business.

#### **5.4. Effect of Open Fifth/Seventh Freedoms Unilaterally**

As noted above, particular circumstances in the US aviation environment have resulted in the emergence of dedicated air cargo carriers and air express carriers as the major force in the air cargo business within the United States – whether this is general air cargo, or parcels, packages and other high value/low volume or perishable items. In the distant past, however, most air



services agreements were built on rights to carry passengers. Airlines' rights to carry cargo have frequently depended wholly on the use of belly space in passenger aircraft. This former bias is in the process of being remedied, but there are still many aviation markets on which no specific air cargo rights have been negotiated. While this situation is a matter of little concern to airlines without dedicated cargo aircraft, or with negligible cargo businesses, it is clearly much more important to those airlines with substantial air cargo businesses. For dedicated air cargo carriers, the issue is critical. Specific attention needs to be given to the optimal air traffic needs of dedicated cargo carriers and airlines with dedicated freighters in their fleet, but this should not occur in the absence of a balanced approach which takes account of the entire spectrum of air cargo and passenger services.

As a case in point, there have been calls for Hong Kong to liberalize the fifth/seventh freedom rights for the air cargo business unilaterally. If Hong Kong unilaterally opened its fifth and seventh freedom cargo rights to the US, Hong Kong carriers would be at a competitive disadvantage to the US carriers. First, since the US domestic market, the world's largest air cargo market, is open only to US carriers (no cabotage), Hong Kong carriers will, other things being equal, have a higher unit cost than US carriers. This is because there are economies of scale and economies of network in the airline business. Second, the US carriers may be able to serve Hong Kong-Asian routes more freely than Hong Kong carriers, in particular while countries around Asia continue to maintain restrictive bilateral treaties with Hong Kong (Dodwell and Zhang, 2000).

Hong Kong's airlines use the belly space in passenger aircraft to carry cargo (55-60%). In addition, cargo revenue account for more than 26% of Cathay Pacific's total revenue. The passenger and cargo markets are not independent to each other. A liberalization of air cargo service will have impacts on the service to passengers. If Hong Kong unilaterally opened its fifth/seventh freedom cargo rights, foreign carriers will enter the market. The immediate result will be a drop in prices and an increase in the volume of cargo services. However, Hong Kong carriers would lose a significant amount of business to foreign airlines under a great disparity in the market share of domestic carriers and foreign mega-carriers. The reduction in cargo business will further raise the cost of operating "combi" aircraft, since passenger and cargo are jointly

produced and there are economies of scope and scale. The Hong Kong airlines will then reduce their passenger output by cutting frequency. The foreign all-passenger airlines will increase their passenger output, leading to a situation where Hong Kong “combi” carriers lose market share and profit in both markets. Of course, the adverse effect on the home carriers does not necessarily imply that the policy is also detrimental to Hong Kong. The Hong Kong economy as a whole might benefit if users (shippers, passengers) could enjoy lower user charges, better network connections and better services. Nonetheless, there is a strong body of evidence worldwide to suggest that success of a hub depends heavily on the successful development home carriers.

## 6. Concluding Remarks

The air cargo volume throughout the world has strongly linked to trade growth and has grown at between 1.5 and 2 times the rate of worldwide GDP growth. Average annual growth in freight-tonne kilometres on international scheduled services during the last decade is 7.9%. In addition, both the JIT pressures and the vertical integration of the logistics industry have led to much faster growth in the air express market than the total air cargo market. Annual growth in international express has averaged nearly 24% since 1992. Finally, E-commerce is likely to generate increased demand for air cargo, particularly the time-definite, express market.

Future air cargo growth may however be constrained by the current international regulatory framework. There have been calls from users (manufacturers, shippers and traders) and air carriers to liberalize the sector. One prominent proposal is to include all-cargo services and express delivery services under the GATS, that is, to have “open skies” for air cargo services. This paper has discussed basic characteristics of the air cargo industry. The implications for air cargo liberalization are as follows:

- All-cargo carriers sometimes have different routing needs and priorities than passenger carriers. It is for this reason (among others) that all-cargo carriers argue that separate all-cargo air traffic rights need to be negotiated, quite distinct from the air traffic rights negotiated in bilateral air services agreements on behalf of passenger carriers.
- Cargo carriers also face their own scheduling difficulties because of the directional imbalance of air cargo. For instance, air freighters may be fully laden when travelling eastbound from

Asia to the US, or westbound to Europe, but then fly back to Asia with much lighter cargo loads. This can mean that they require different sets of air traffic rights from those needed or prioritised by passenger carriers.

- The ability to funnel traffic to one location (and changing aircraft) does not always work for air cargo. Air cargo traffic is predominantly focused only on a few flows that are based around centers of production and consumption. These flows are best met by substantial capacity on direct flights. The key determinant for air cargo volumes for most airports is the size and scope of local O&D market whether for exports or imports.
- On the other hand, hub-and-spoke systems work for smaller flows that are diffuse in nature and uneconomic to fly directly. This market is being catered for through the growth of express operations that specialize in these flows along with door-to-door distribution. Therefore, hubbing makes sense to express operators who handle smaller, diffuse flows. However, even for express operators, developing cargo hub-and-spoke operations needs to take into account the size and scope of the local O&D market.
- Strategies that work for the passenger business may not be conducive for the cargo business. For example, strategic alliances, in which partner airlines share route networks, capacities and develop unified products, have generally worked well for the passenger market, but they appear to have little bearing on air cargo. If they do exist, air cargo alliances are more likely to occur for specific markets rather than on a regional or global scale, in contrast to air passenger alliances.
- The air cargo business in Asia is not likely to develop as the US market has developed, since Asian passenger carriers rely heavily on air cargo carriage as part of their overall business model. Dedicated all-cargo carriers will grow business strongly, but are unlikely to gain the massive market share that they have won in the US.
- Separation of air cargo and passenger rights will be fraught with difficulty in Asia because of distinctive characteristics of the air cargo market, in which most passenger carriers have substantial cargo business, and operate wide-bodied fleets. This is not the case in the US, where passenger carriers rely on cargo business for only a small proportion of revenue and thus are indifferent to segregation of air cargo and passenger rights.
- As a consequence, liberalizing the air cargo sector first may result in differential impacts on the US and Asian carriers, and separation of air cargo and passenger rights may be fraught

with difficulty because of the distinctive inter-linkage of passenger and air cargo business in Asia. In effect, IATA is still yet to develop an industry view on the proposal.

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THE IMPLICATION OF HUB AND  
SPOKE NETWORK ON THE AIRLINE  
ALLIANCE STRATEGY

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## ABSTRACT

The structure of an airline's network plays an important role in the development of airline's strategy. In this paper, a theoretical model supposing two airlines' hub and spoke networks investigates the effects of different strategies on the airlines outputs, profits and economic welfare. The model simulates the market results of two profit-maximizing airlines under the basic form of bilateral agreement, the partial alliance and the complete alliance. It is found that firstly, the basic bilateral agreement, which combines the two airlines' separate networks, stimulates more local and connecting traffic. Passengers are better off for the increased service as well as the reduced airfare. The profits for both airlines increase after the agreement for the extensive network and the economies of traffic density. Consequently, the basic form of the bilateral agreement definitely improves the economic welfare. Secondly, under the background of the bilateral agreement, two airlines make partial alliance by which they jointly offer the inter-hubbing flights. After the alliance, the output between the hub cities decreases, while the flights on the local and connecting markets increase for both airlines. Though passengers are worse off on the inter-hubbing market, they benefit from the increase of service and the decrease of airfare on other markets. As market size gets larger, the gains to passengers become high enough to compensate for the losses to them. Therefore, consumer surplus increases for the partial alliance. Furthermore it is shown that the total profits of the two airlines increase for the partial alliance and the increase of the profits gets larger as the market size increases. As for the change of economic welfare, it is found that in most conditions, it increases due to the partial alliance. The paper also shows that when increasing return to traffic density is relatively strong, the partial alliance tends to increase the economic welfare at the lower market size. On the other hand, when increasing return to density is relatively weak, the rise of the economic welfare results from the higher value of the market size. Finally, the complete alliance is examined under which the two airlines make the most extensive strategic alliance within their networks as compared to the situation of the open sky bilateral agreement where no alliance exists. The results show that the complete alliance makes the passengers whose flights are within an airline's network better off, but for those passengers on the markets combining the two airlines networks', they are worse off due to the complete alliance. As for the two airlines, their total profits decrease for the complete alliance and the losses get larger as the market size increases. Consequently, the complete alliance makes the economic welfare deteriorate. From these conclusions, some explanation and policy implication are developed.

## 1. INTRODUCTION

There are two significant developments in the air transport industry in recent years. The first of these was the emergence of the hub and spoke network following the deregulation of U.S. air transport in 1978. Airlines use hubs to consolidate traffic and therefore to take advantage of economies of traffic density. Through consolidation, airlines can offer direct services to more places at higher frequency and lower unit costs, using larger aircrafts. Passengers also benefit from the hub and spoke network for the increased frequency of flights and more choices of routes. Secondly, more and more airlines have been extending their service networks by strategic alliances with other airlines to form global service networks.

Several reasons can explain the two phenomena. For example, passengers always prefer an airline with an extensive international network. This preference motivates airlines to establish global networks to attract more passengers in the increasingly competitive markets. However, it is difficult for an airline to establish a truly efficient network in foreign continents. Furthermore, it is known that most passengers prefer the on-line connecting services to the inter-line connecting services provided by two or more different airlines. High frequency and flexible schedule are also attractive factors of an airline to passengers, especially those business passengers. The above characteristics of the demand side drive airlines to transform from the initial point-point linear network to the hub and spoke network in its own route pattern. As for the connection with other airlines' networks, it is not surprising that the strategic alliance among airlines is an efficient means for an airline to extend its service network. On the cost side, the common factor behind these two trends is the economies of traffic density. Economies of density arise because high density enables airline to use larger aircraft more efficiently at higher load factor. Therefore, the marginal cost of carrying an extra passenger on an individual route segment falls as traffic on the route rises. By the switch to hub and spoke network, airlines consolidate traffic from many different origin-destination markets into a much smaller number of links in the network and raise the traffic density on spoke routes. On each spoke, airlines can carry passengers with the same origin but different destinations, or passengers with the same destination but different origins. As for the strategic alliance, it not only extends the airline's service network into the partner airline's



network. More importantly, it consolidates passengers originally served by the two airlines on the route they jointly operate. Therefore, the alliance partners also benefit from the economies of traffic density intrinsically in the air transport network.

In this paper, I construct a model consisting of two airlines in two nations, each of which has its own hub and spoke network structure. The stretch of the model development is summarized as follows. Firstly, the two airline networks are separate each other on the assumption that no bilateral agreement exists. Then the simple form of bilateral agreement between the two countries combines the two airlines' networks and airlines compete on the route connecting their hub cities. Depending on the regulatory regime, I consider the two types of alliance. Under the regime of the simple form bilateral agreement, each airline can fly to another one's hub city via its own hub and thus the two separate networks are connected. For example, the U.S.-China Civil Air Transport Agreement amended in 1995 authorized Minnesota-based Northwest Airline and the Beijing-based Air China the right to fly between Detroit and Beijing. But for Northwest Airline, it has no right to fly beyond Beijing. The partial alliance is based on such restrictive bilateral agreement. It is assumed that the two airlines make alliance on the route between the two hub cities, considering the case that Korean Air and Air Canada code shared their flights on the Seoul-Vancouver routes. Under the regime of the open sky bilateral agreement, complete alliance is studied in the model. For example, the open sky air treaty between the U.S. and Netherlands allowed KLM to operate open-shared flights with Northwest to more than 80 U.S. cities beyond NW's hub. The purpose of this paper is to analyze the effects on outputs, airline profits and economic welfare of these two types of airline alliance and investigate the effects under different market sizes and extents of economies to traffic density.

The next section reviews studies on the hub & spoke network and the airline alliance strategy. In section 3, the theoretical model is developed on the basis of profit maximization assumption of two airlines, each of which has an individual hub and spoke network. Section 4 investigates the effects on the output and airlines' profits of bilateral agreement, partial alliance under the regime of simple bilateral agreement, and complete alliance under the open-sky bilateral agreement. In section 5, some simulation work is

done to examine the effects on the consumer surplus and economic welfare respectively. Conclusion and some policy implication are made in section 6.

## **2. LITERATURE REVIEW**

The earlier work about the study on the economies of traffic density in air transport network was attempted by Douglas Caves, Laurits Christensen and Michael Tretheway(1984). Their work estimated the economies of density by analyzing the relationship between airline total costs, network size and the magnitude of passenger and freight services provided. The study using the panel data of U.S. trunk and local service airlines during the period 1970-1981 found that the difference in scale has no significant effect in explaining the different costs of airlines, while the factor of great significance was the density of traffic within airline's network. Given the unchanged airline's route structure, total cost increased 80 percent as rapidly as total traffic, implying the significant existence of increasing return to traffic density.

Brueckner and Spiller(1994) investigated the strength of economies of traffic density on individual route segment using a structural model of a simple hub and spoke network that connects three endpoints out of a hub city. The marginal cost of serving a passenger is determined by the marginal costs of the spokes along which he travels. Therefore, the marginal cost of serving a connecting passenger is the summation of the marginal cost of each segment he flies. This point illustrated the characteristic of cost complementarities across markets. The empirical work using the data of U.S. airlines in the fourth quarter of 1985 found that the marginal cost of carrying a passenger along a spoke route had significantly inverse relation with the traffic density and the airfares were low in a city-pair market when traffic densities on the spokes connecting the market cities were high, both of which strengthened the density effect in air transport network. As compared to the previous study, Brueckner and Spiller included the density information at the individual route level focusing on the hub and spoke network structure and their estimated economies of traffic density turned out to be stronger.

The theoretical analysis examining the effects of alliance on airlines' outputs, profits and economic welfare was made by Park(1997). The model he established consisted of three airlines operating in a network including three gateway cities. In the model, the effects of parallel alliance and complementary alliance as compared to the pre-alliance condition were examined respectively. By parallel alliance, two airlines make alliance on the route they compete each other before alliance. While by complementary alliance, the two partners jointly connect the two- flight segments on which they operate seperately before alliance. Therefore, the connecting flights now jointly provided by the two alliance partners compete with that offered by the other airline. The result showed that the two types of alliances had different effects on output and economic welfare. Economic welfare rises due to the complementary alliance, while parallel alliance tended to decrease it.

In my paper, the same theoretical analysis method is taken and the differences are in the model construction and problem discussed. Instead of using the same network consisting of three cities for three airlines, the model I construct solves the situation for two airlines, each of which has its own hub and spoke network. In reality, these two airlines can be those in two different countries or continents. The alliance between them under different regulatory regime can be partial alliance referring to the alliance on their inter-hub city pair market, or complete alliance indicating the alliance on the most extensive city pair markets within their networks. Then the effects of these two types of alliance are examined respectively.

The theoretical model developed in Park (1997) used two important research results on the airline industry. Firstly, Cournot model was supposed in the competition of the airline industry. Brander and Zhang (1990) used the data of 33 Chicago-based airline duopoly routes for the third quarter of 1985 and found that the airlines' conduct most reasonably appropriated Cournot behavior. In fact, the Bertrand and cartel models were also considered in the article, while the sensitive analyses on the basis of the data set were more consistent with the assumption of Cournot model. The second important finding was made by Brueckner and Spiller(1991). In that paper, a simple model of a hub and spoke network was firstly constructed to analyze the welfare effects of competition

within the network. Capturing the cost complementarities and economies of traffic density inherent in the hub and spoke network, the structure model assumed the linear demand and marginal cost function on each flight leg of the network. On the basis of the profit maximization and Cournot equilibrium, different forms of competition within the network were considered to investigate their effects on the economic welfare.

Researchers also studied the effects of strategic alliance on airfares, traffic volume and consumer surplus empirically. Park and Zhang(1997) used the panel data of four major alliances in North Atlantic market in the period 1990-1994 to examine the effects of strategic alliance. Their results showed that the equilibrium airfares decreased on the routes where alliances occurred and the annual passenger volume increased, and consumers were better off after the alliance.

In recent years, code-sharing agreement between airlines has become an essential form of airline alliance. It is a market arrangement between two airlines by which one airline's designator code is shown on flights operated by its partner airline. The complementary code sharing agreement occurs when the two partners link up their networks together and feed traffic between domestic and international routes. Oum et al. (1996) used a panel data of 57 transpacific air routes in the period 1982-1992 and found empirically that the complementary code sharing alliance between non-leader partners led to the increase of the leader's output and the decrease of the leader's airfare. Such results were not consistent with the finding in the theoretical model by Park (1997) which argued that the leader airline produced less output under the same situation. The inconsistency resulted from the ignorance of the traffic-enhancing effect in the theoretical model. It was argued that the complementary code sharing alliance between non- leaders not only made the leader airline face competition and thus lose its traffic (the competitive effects), but also had the effect of increasing the traffic demand (the traffic-enhancing effects). In reality, the traffic enhancing effects may outweigh the competitive effects. Therefore, it was not surprising that the leader's output increased. While, in the theoretical model, it was assumed that there were no such demand shifts after the alliance, and thus the significant traffic enhancing effects were ignored. The same limitation exists in my model

construction, and I am thinking to include a demand- shifting coefficient due to alliance in the further study.

Recently, more studies on strategic airline alliance emphasize the stability of the airline alliance, the international regulatory issues with the alliance and the future evolution of the alliance. Oum and Park(1997) concluded that the strategic alliances among major airlines would be strengthened in the future and they envisioned the emergence of the competing global alliance networks. Yu et al. (2001) proposed the desirable international regulatory structure on alliances. Considering the asymmetrical regulatory policy across countries and uneven progress on the deregulation and liberalization across regions in world airline industry, the convergence of national competition policies and the coordination of regulatory agencies are necessary to deal with the problems with the international airline alliances.

### 3. THE MODEL

#### 3.1. No bilateral agreement model

As depicted in fig 3.1, consider two airlines (designated by airline 1 and 2) each operating its own network HAB and KCD. Before the two countries make the bilateral agreement, these two networks are separated and each airline has a local monopoly power on its hub and spoke network.



Figure 3.1 No bilateral agreement model

For airline 1, its network consists of A, H and B, where H is the hub connecting traffic between A and B. Airline 2's network consists of K, C and D with hub K. In each network, there are three city-pair markets, while aircrafts are flown only on two spoke routes owing to the nature of hub and spoke network.

For the convenience of analysis, demand is assumed to be symmetric across city-pairs. Let  $D(Q_i)$  be an inverse demand function for round-trip travel in market  $i$  ( $i = AH, BH, AB, CK, DK$  and  $CD$ ) where  $Q_i$  represents the number of round-trip passengers in the market  $i$ . Furthermore, a common cost function, denoted as  $C(Q)$ , is assumed for the cost of carrying  $Q$  passengers on each leg of the network. The cost function should reflect increasing returns to traffic density, satisfying  $C'(Q) > 0$  and  $C''(Q) < 0$ .

The demand function has the form:

$$D(Q) = \alpha - Q/2, \alpha > 0$$

where  $\alpha$  represents the demand level on each city pair. As for the cost function, it has the form:

$$C'(Q) = 1 - \theta Q, \theta > 0$$

where  $\theta$  measures the extent of increasing return to traffic density. The higher value of  $\theta$  shows the higher degree of increasing return to traffic density.

Before making bilateral agreements, each carrier operates its network separately. Given the assumptions above, each airline's profit function can be expressed as:

$$\pi_1 = Q_{AH}D(Q_{AH}) + Q_{BH}D(Q_{BH}) + Q_{AB}D(Q_{AB}) - C(Q_{AH} + Q_{AB}) - C(Q_{BH} + Q_{AB}),$$

$$\pi_2 = Q_{CK}D(Q_{CK}) + Q_{DK}D(Q_{DK}) + Q_{CD}D(Q_{CD}) - C(Q_{CK} + Q_{CD}) - C(Q_{DK} + Q_{CD}).$$

For carrier 1, the first-order condition for profit maximization is:

$$D(Q_{AH}^1) + Q_{AH}^1 \cdot D'(Q_{AH}^1) = C'(Q_{AH}^1 + Q_{AB}^1)$$

$$D(Q_{BH}^1) + Q_{BH}^1 \cdot D'(Q_{BH}^1) = C'(Q_{BH}^1 + Q_{AB}^1)$$

$$D(Q_{AB}^1) + Q_{AB}^1 \cdot D'(Q_{AB}^1) = C'(Q_{AH}^1 + Q_{AB}^1) + C'(Q_{BH}^1 + Q_{AB}^1)$$

It can be written as follows:

$$\alpha - Q_{AH} = 1 - \theta(Q_{AH} + Q_{AB})$$

$$\alpha - Q_{BH} = 1 - \theta(Q_{BH} + Q_{AB})$$

$$\alpha - Q_{AB} = 2 - \theta(Q_{AH} + Q_{AB}) - \theta(Q_{BH} + Q_{AB})$$

The left side of above equations represents the marginal revenue in each city pair market, which is set to equal the marginal cost of serving a passenger in that market. The cost

complementary property of the network, which is an intrinsic feature of hub and spoke system, is apparently shown on the right side of equation, for example, the marginal cost of serving a passenger in the market AH falls when either  $Q_{AH}$  (local traffic) or  $Q_{AB}$  (connecting traffic) increases.

The results are as follows:

$$Q_{AH}^1 = Q_{BH}^1 = \frac{\alpha - \alpha\theta - 1}{1 - 3\theta}$$

$$Q_{AB}^1 = \frac{\alpha + \alpha\theta - 2}{1 - 3\theta}$$

It is shown that the second-order condition for the airline's profit maximization problem reduces to  $\theta < \frac{1}{3}$ . By the requirements of the positive values for the marginal revenue

(marginal cost) and the output,  $\alpha$  is constrained as  $\frac{2}{1+\theta} < \alpha < \frac{1}{2\theta}$ .

In order to get the profit value, I assume that the fixed costs associated with each leg operations are a constant. For the simplicity of the model, it is assumed to be zero. Therefore, the cost function on each leg has the form:

$$C = Q - \frac{\theta}{2} Q^2$$

For airline 1, since its profit function has the form:

$$\pi_1 = Q_{AH} D(Q_{AH}) + Q_{BH} D(Q_{BH}) + Q_{AB} D(Q_{AB}) - C(Q_{AH} + Q_{AB}) - C(Q_{BH} + Q_{AB})$$

From the above results, the profit is:

$$\pi_1 = \frac{-3(-2 + \alpha\theta^2 + 6\theta) + \alpha[-8 + \alpha(3 - 10\theta) + 6(4 + \alpha\theta)\theta]}{2(1 - 3\theta)^2}$$

$$\text{Or, } \pi_1 = \frac{-6 + 8\alpha - 3\alpha^2 + 3\alpha\theta^2 + 18\theta - 24\alpha\theta + 10\alpha^2\theta - 6\alpha^2\theta^2}{2(3\theta - 1)^2}$$

The same result can be applied to airline 2 for the symmetrical assumption.

### 3.2. After-bilateral agreement model

Now consider the situation when the two countries sign the bilateral agreements, then both airlines can fly between their two hub cities, i.e., H and K. Furthermore, for passengers from city A, they can fly from A to K through the airline 1's hub H, and passengers in B can also fly to K by connecting service offered by airline 1 through hub H.

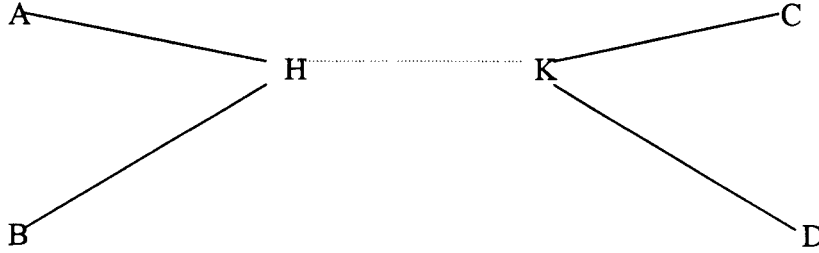


Figure 3.2. After bilateral agreement model

By such an agreement, the two airlines (1 and 2) compete on the route HK. The following model examines the effect of that competition on the two airlines' outputs and profits.

After the bilateral agreements, the profit functions for both airlines can be expressed as:

$$\begin{aligned}\pi_1 &= Q_{AH} D(Q_{AH}) + Q_{BH} D(Q_{BH}) + Q_{AK} D(Q_{AK}) + Q_{BK} D(Q_{BK}) + Q_{AB} D(Q_{AB}) + Q_{HK}^1 D(Q_{HK}^1 + Q_{HK}^2) \\ &\quad - C(Q_{AH} + Q_{AK} + Q_{AB}) - C(Q_{BH} + Q_{BK} + Q_{AB}) - C(Q_{HK}^1 + Q_{AK} + Q_{BK}) \\ \pi_2 &= Q_{CK} D(Q_{CK}) + Q_{DK} D(Q_{DK}) + Q_{CH} D(Q_{CH}) + Q_{DH} D(Q_{DH}) + Q_{CD} D(Q_{CD}) + Q_{HK}^2 D(Q_{HK}^2 + Q_{HK}^1) \\ &\quad - C(Q_{CH} + Q_{CK} + Q_{CD}) - C(Q_{DK} + Q_{DH} + Q_{CD}) - C(Q_{HK}^2 + Q_{CH} + Q_{DH})\end{aligned}$$

Given the above equations, airline 1's first order conditions are:

$$\alpha - Q_{AH} = 1 - \theta(Q_{AH} + Q_{AK} + Q_{AB}) \quad (3)$$

$$\alpha - Q_{BH} = 1 - \theta(Q_{BH} + Q_{BK} + Q_{AB}) \quad (4)$$

$$\alpha - Q_{AK} = 2 - \theta(Q_{AH} + Q_{AK} + Q_{AB}) - \theta(Q_{HK}^1 + Q_{AK} + Q_{BK}) \quad (5)$$

$$\alpha - Q_{BK} = 2 - \theta(Q_{BH} + Q_{BK} + Q_{AB}) - \theta(Q_{HK}^1 + Q_{AK} + Q_{BK}) \quad (6)$$

$$\alpha - Q_{AB} = 2 - \theta(Q_{AH} + Q_{AK} + Q_{AB}) - \theta(Q_{BH} + Q_{BK} + Q_{AB}) \quad (7)$$

$$\alpha - Q_{HK}^1 - \frac{Q_{HK}^2}{2} = 1 - \theta(Q_{HK}^1 + Q_{AK} + Q_{BK}) \quad (8)$$



And for airline 2, the first order conditions are:

$$\alpha - Q_{CK} = 1 - \theta(Q_{CK} + Q_{CH} + Q_{CD})$$

$$\alpha - Q_{DK} = 1 - \theta(Q_{DK} + Q_{DH} + Q_{CD})$$

$$\alpha - Q_{CH} = 2 - \theta(Q_{CK} + Q_{CH} + Q_{CD}) - \theta(Q_{HK}^2 + Q_{CH} + Q_{DH})$$

$$\alpha - Q_{DH} = 2 - \theta(Q_{DK} + Q_{DH} + Q_{CD}) - \theta(Q_{HK}^2 + Q_{CH} + Q_{DH})$$

$$\alpha - Q_{CD} = 2 - \theta(Q_{CK} + Q_{CH} + Q_{CD}) - \theta(Q_{DK} + Q_{DH} + Q_{CD})$$

$$\alpha - Q_{HK}^2 - \frac{Q_{HK}^1}{2} = 1 - \theta(Q_{HK}^2 + Q_{CH} + Q_{DH})$$

Now consider the equilibrium arises when the two airlines play a Cournot game in the common market, i.e., the city pair between H and K. Note that the left-hand side of the equation (3)-(8) represents the marginal revenue in each market of airline 1, which are set to equal the marginal cost of serving a passenger in the market. Referring to equation (3), for example, the marginal cost of serving a passenger in the AH market falls when either local traffic  $Q_{AH}$  or connecting traffic  $Q_{AK}$ ,  $Q_{AB}$  increases.

For the symmetrical assumption, I can suppose that  $Q_{HK}^1 = Q_{HK}^2$ . Then the solutions from the above equations are:

$$Q_{AH} = Q_{BH} = \frac{(5\theta - 3)[1 + \alpha(2\theta - 1)]}{3 - 20\theta + 26\theta^2}$$

$$Q_{AK} = Q_{BK} = \frac{-6 + 11\theta + \alpha[3 - \theta(3 + 4\theta)]}{3 - 20\theta + 26\theta^2}$$

$$Q_{AB} = \frac{-6 + 10\theta + \alpha[3 - 2\theta(1 + 3\theta)]}{3 - 20\theta + 26\theta^2}$$

$$Q_{HK}^1 = Q_{HK}^2 = \frac{2(2\theta - 1)[1 + \alpha(2\theta - 1)]}{3 - 20\theta + 26\theta^2}$$

As for airline 2, it has the solution as the following:

$$Q_{CK} = Q_{DK} = \frac{(5\theta - 3)[1 + \alpha(2\theta - 1)]}{3 - 20\theta + 26\theta^2}$$

$$Q_{CH} = Q_{DH} = \frac{-6 + 11\theta + \alpha[3 - \theta(3 + 4\theta)]}{3 - 20\theta + 26\theta^2}$$

$$Q_{CD} = \frac{-6 + 10\theta + \alpha[3 - 2\theta(1 + 3\theta)]}{3 - 20\theta + 26\theta^2}$$

$$Q_{HK}^2 = \frac{2(2\theta - 1)[1 + \alpha(2\theta - 1)]}{3 - 20\theta + 26\theta^2}$$

The second order condition for the profit maximization problem reduces to  $\theta < \frac{1}{26}(10 - \sqrt{22}) \approx 0.204$ . And the positive marginal revenue (cost) and the output

require  $\alpha$  such that  $\frac{1}{1-2\theta} < \alpha < \frac{3-5\theta}{-16\theta^2+9\theta}$ .

From the above results, the profit for airline 1 is as the following:

$$\pi_1 = \frac{A + 4\alpha B + \alpha^2 C}{2(3 - 20\theta + 26\theta^2)^2}$$

where  $A = 130 - 1106\theta + 2696\theta^2 - 2028\theta^3$

$$B = -38 + 323\theta - 786\theta^2 + 590\theta^3$$

$$C = 49 - 438\theta + 1196\theta^2 - 1204\theta^3 + 332\theta^4$$

And for airline 2, it has the same profit expression.

### 3.3 Partial alliance model

Under such restrictive bilateral agreement, suppose now these two airlines make alliance. By the partial alliance, I mean that the two airlines jointly provide the flight between two hub cities H and K. After alliance the profit function for airline 1 and 2 can be expressed as:

$$\begin{aligned} \pi_{1+2} = & Q_{AH}^1 D(Q_{AH}^1) + Q_{BH}^1 D(Q_{BH}^1) + Q_{AB}^1 D(Q_{AB}^1) + Q_{AK}^1 D(Q_{AK}^1) + Q_{BK}^1 D(Q_{BK}^1) + Q_{HK}^{1\&2} D(Q_{HK}^{1\&2}) \\ & + Q_{CK}^2 D(Q_{CK}^2) + Q_{DK}^2 D(Q_{DK}^2) + Q_{CD}^2 D(Q_{CD}^2) + Q_{CH}^2 D(Q_{CH}^2) + Q_{DH}^2 D(Q_{DH}^2) - C(Q_{AH}^1 + Q_{AK}^1 + Q_{AB}^1) \\ & - C(Q_{BH}^1 + Q_{BK}^1 + Q_{AB}^1) - C(Q_{AK}^1 + Q_{BK}^1 + Q_{HK}^{1\&2} + Q_{CH}^2 + Q_{DH}^2) - C(Q_{CK}^2 + Q_{CH}^2 + Q_{CD}^2) - C(Q_{DK}^2 + Q_{DH}^2) \end{aligned}$$

And the first order condition for the joint profit maximization now becomes:

$$\alpha - Q_{AH}^1 = 1 - \theta(Q_{AH}^1 + Q_{AK}^1 + Q_{AB}^1)$$

$$\alpha - Q_{BH}^1 = 1 - \theta(Q_{BH}^1 + Q_{BK}^1 + Q_{AB}^1)$$

$$\alpha - Q_{AB}^1 = 2 - \theta(Q_{AH}^1 + Q_{AK}^1 + Q_{AB}^1) - \theta(Q_{BH}^1 + Q_{BK}^1 + Q_{AB}^1)$$

$$\alpha - Q_{AK}^1 = 2 - \theta(Q_{AH}^1 + Q_{AK}^1 + Q_{AB}^1) - \theta(Q_{AK}^1 + Q_{BK}^1 + Q_{HK}^{1\&2} + Q_{CH}^2 + Q_{DH}^2) \quad a$$

$$\alpha - Q_{BK}^1 = 2 - \theta(Q_{BH}^1 + Q_{BK}^1 + Q_{AB}^1) - \theta(Q_{AK}^1 + Q_{BK}^1 + Q_{HK}^{1\&2} + Q_{CH}^2 + Q_{DH}^2) \quad b$$

$$\alpha - Q_{HK}^{1\&2} = 1 - \theta(Q_{AK}^1 + Q_{BK}^1 + Q_{HK}^{1\&2} + Q_{CH}^2 + Q_{DH}^2) \quad c$$

$$\alpha - Q_{CK}^2 = 1 - \theta(Q_{CK}^2 + Q_{CH}^2 + Q_{CD}^2)$$

$$\alpha - Q_{DK}^2 = 1 - \theta(Q_{DK}^2 + Q_{DH}^2 + Q_{CD}^2)$$

$$\alpha - Q_{CD}^2 = 2 - \theta(Q_{CK}^2 + Q_{CH}^2 + Q_{CD}^2) - \theta(Q_{DK}^2 + Q_{DH}^2 + Q_{CD}^2)$$

$$\alpha - Q_{CH}^2 = 2 - \theta(Q_{AK}^1 + Q_{BK}^1 + Q_{HK}^{1\&2} + Q_{CH}^2 + Q_{DH}^2) - \theta(Q_{CK}^2 + Q_{CH}^2 + Q_{CD}^2) \quad c$$

$$\alpha - Q_{DH}^2 = 2 - \theta(Q_{AK}^1 + Q_{BK}^1 + Q_{HK}^{1\&2} + Q_{CH}^2 + Q_{DH}^2) - \theta(Q_{DK}^2 + Q_{DH}^2 + Q_{CD}^2) \quad d$$

Solve the equations above, and the solutions are as the following:

$$Q_{AH}^1 = Q_{BH}^1 = Q_{CK}^2 = Q_{DK}^2 = \frac{6\alpha\theta^2 - 6\alpha\theta + 4\theta + \alpha - 1}{1 - 9\theta + 16\theta^2}$$

$$Q_{AK}^1 = Q_{BK}^1 = Q_{CH}^2 = Q_{DH}^2 = \frac{-2\alpha\theta^2 - \alpha\theta + 4\theta + \alpha - 2}{1 - 9\theta + 16\theta^2}$$

$$Q_{AB}^1 = Q_{CD}^2 = \frac{-4\alpha\theta^2 - 3\alpha\theta + 8\theta + \alpha - 2}{1 - 9\theta + 16\theta^2}$$

$$Q_{HK}^{1\&2} = \frac{8\alpha\theta^2 - 4\alpha\theta + \alpha - 1}{1 - 9\theta + 16\theta^2}$$

The second order condition for the partial alliance profit maximization problem reduces to  $\theta < \frac{1}{32}(9 - \sqrt{17}) \approx 0.152$ . Positive outputs and marginal revenue (costs) require

$$\alpha \text{ such that } \frac{4\theta - 2}{2\theta^2 + \theta - 1} < \alpha < \frac{1}{5\theta - 8\theta^2}.$$

Under the partial alliance, the total profits for these two airlines can be computed from the above solutions as  $\pi^{1\&2} = \frac{29 - 34\alpha + 11\alpha^2 - 80\theta + 96\alpha\theta - 38\alpha^2\theta + 16\alpha^2\theta^2}{2 - 18\theta + 32\theta^2}$ .

### 3.4. Bilateral agreement (open –sky agreement)

Under the open-sky agreement, each airline has the complete rights to fly in the other one's network. If the network is within the country's territory, such right is called as the cabotage. Or it can be extended to the third country by the fifth-freedom rights.

#### 3.4.1. No alliance situation

Under this kind of bilateral agreement, firstly consider the situation without alliance. The two airlines can serve any city-pair in the expanded network. Suppose they compete with each other on every city-pair market. Then the profit function for airline 1 is:

$$\begin{aligned}
\pi_1 = & Q_{AH}^1 D(Q_{AH}^1 + Q_{AH}^2) + Q_{BH}^1 D(Q_{BH}^1 + Q_{BH}^2) + Q_{AB}^1 D(Q_{AB}^1 + Q_{AB}^2) + Q_{HK}^1 D(Q_{HK}^1 + Q_{HK}^2) + Q_{HC}^1 D(Q_{HC}^1 \\
& + Q_{HC}^2) + Q_{HD}^1 D(Q_{HD}^1 + Q_{HD}^2) + Q_{AK}^1 D(Q_{AK}^1 + Q_{AK}^2) + Q_{BK}^1 D(Q_{BK}^1 + Q_{BK}^2) + Q_{AC}^1 D(Q_{AC}^1 + Q_{AC}^2) + Q_{AD}^1 D(Q_{AD}^1 \\
& + Q_{AD}^2) + Q_{BC}^1 D(Q_{BC}^1 + Q_{BC}^2) + Q_{BD}^1 D(Q_{BD}^1 + Q_{BD}^2) + Q_{CD}^1 D(Q_{CD}^1 + Q_{CD}^2) + Q_{CK}^1 D(Q_{CK}^1 + Q_{CK}^2) + Q_{DK}^1 D(Q_{DK}^1 \\
& + Q_{DK}^2) - C(Q_{AH}^1 + Q_{AB}^1 + Q_{AK}^1 + Q_{AC}^1 + Q_{AD}^1) - C(Q_{BH}^1 + Q_{AB}^1 + Q_{BK}^1 + Q_{BC}^1 + Q_{BD}^1) - C(Q_{HK}^1 + Q_{AK}^1 + Q_{BK}^1 \\
& + Q_{AC}^1 + Q_{AD}^1 + Q_{BC}^1 + Q_{BD}^1 + Q_{HC}^1 + Q_{HD}^1) - C(Q_{CK}^1 + Q_{HC}^1 + Q_{CD}^1 + Q_{BC}^1 + Q_{AC}^1) - C(Q_{DK}^1 + Q_{HD}^1 + Q_{CD}^1 + Q_{AD}^1 \\
& + Q_{BD}^1)
\end{aligned}$$

Similarly, the profit function for airline 2 has the form:

$$\begin{aligned}
\pi_2 = & Q_{AH}^2 D(Q_{AH}^1 + Q_{AH}^2) + Q_{BH}^2 D(Q_{BH}^1 + Q_{BH}^2) + Q_{AB}^2 D(Q_{AB}^1 + Q_{AB}^2) + Q_{HK}^2 D(Q_{HK}^1 + Q_{HK}^2) + Q_{HC}^2 D(Q_{HC}^1 \\
& + Q_{HC}^2) + Q_{HD}^2 D(Q_{HD}^1 + Q_{HD}^2) + Q_{AK}^2 D(Q_{AK}^1 + Q_{AK}^2) + Q_{BK}^2 D(Q_{BK}^1 + Q_{BK}^2) + Q_{AC}^2 D(Q_{AC}^1 + Q_{AC}^2) + Q_{AD}^2 D(Q_{AD}^1 \\
& + Q_{AD}^2) + Q_{BC}^2 D(Q_{BC}^1 + Q_{BC}^2) + Q_{BD}^2 D(Q_{BD}^1 + Q_{BD}^2) + Q_{CD}^2 D(Q_{CD}^1 + Q_{CD}^2) + Q_{CK}^2 D(Q_{CK}^1 + Q_{CK}^2) + Q_{DK}^2 D(Q_{DK}^1 \\
& + Q_{DK}^2) - C(Q_{AH}^2 + Q_{AB}^2 + Q_{AK}^2 + Q_{AC}^2 + Q_{AD}^2) - C(Q_{BH}^2 + Q_{AB}^2 + Q_{BK}^2 + Q_{BC}^2 + Q_{BD}^2) - C(Q_{HK}^2 + Q_{AK}^2 + Q_{BK}^2 \\
& + Q_{AC}^2 + Q_{AD}^2 + Q_{BC}^2 + Q_{BD}^2 + Q_{HC}^2 + Q_{HD}^2) - C(Q_{CK}^2 + Q_{HC}^2 + Q_{CD}^2 + Q_{BC}^2 + Q_{AC}^2) - C(Q_{DK}^2 + Q_{HD}^2 + Q_{CD}^2 + Q_{AD}^2 \\
& + Q_{BD}^2)
\end{aligned}$$

Since the duopoly situation exists on each city-pair market, the equilibrium follows when these two airlines play a Cournot game in each market of this expanded network.

For airline 1, the first order condition for profit maximization before alliance can be written as follows:

$$\alpha - Q_{AH}^1 - \frac{Q_{AH}^2}{2} = 1 - \theta A$$

$$\alpha - Q_{BH}^1 - \frac{Q_{BH}^2}{2} = 1 - \theta B$$

$$\alpha - Q_{AB}^1 - \frac{Q_{AB}^2}{2} = 2 - \theta A - \theta B$$

$$\alpha - Q_{HK}^1 - \frac{Q_{HK}^2}{2} = 1 - \theta C$$

$$\alpha - Q_{HC}^1 - \frac{Q_{HC}^2}{2} = 2 - \theta C - \theta D$$

$$\alpha - Q_{HD}^1 - \frac{Q_{HD}^2}{2} = 2 - \theta C - \theta E$$

$$\alpha - Q_{AK}^1 - \frac{Q_{AK}^2}{2} = 2 - \theta A - \theta C$$

$$\alpha - Q_{BK}^1 - \frac{Q_{BK}^2}{2} = 2 - \theta B - \theta C$$

$$\alpha - Q_{AC}^1 - \frac{Q_{AC}^2}{2} = 3 - \theta A - \theta C - \theta D$$

$$\alpha - Q_{AD}^1 - \frac{Q_{AD}^2}{2} = 3 - \theta A - \theta C - \theta E$$

$$\alpha - Q_{BC}^1 - \frac{Q_{BC}^2}{2} = 3 - \theta B - \theta C - \theta D$$

$$\alpha - Q_{BD}^1 - \frac{Q_{BD}^2}{2} = 3 - \theta B - \theta C - \theta E$$

$$\alpha - Q_{CD}^1 - \frac{Q_{CD}^2}{2} = 2 - \theta D - \theta E$$

$$\alpha - Q_{CK}^1 - \frac{Q_{CK}^2}{2} = 1 - \theta D$$

$$\alpha - Q_{DK}^1 - \frac{Q_{DK}^2}{2} = 1 - \theta E$$

$$\text{where } A = Q_{AH}^1 + Q_{AB}^1 + Q_{AK}^1 + Q_{AC}^1 + Q_{AD}^1$$

$$B = Q_{BH}^1 + Q_{AB}^1 + Q_{BK}^1 + Q_{BD}^1 + Q_{BC}^1$$

$$C = Q_{HK}^1 + Q_{AK}^1 + Q_{BK}^1 + Q_{AC}^1 + Q_{AD}^1 + Q_{BC}^1 + Q_{BD}^1 + Q_{HC}^1 + Q_{HD}^1$$

$$D = Q_{CK}^1 + Q_{HC}^1 + Q_{CD}^1 + Q_{BC}^1 + Q_{AC}^1$$

$$E = Q_{DK}^1 + Q_{HD}^1 + Q_{CD}^1 + Q_{BD}^1 + Q_{AD}^1$$

As for airline 2, the first-order condition can be similarly written as:

$$\alpha - Q_{AH}^2 - \frac{Q_{AH}^1}{2} = 1 - \theta A'$$

$$\alpha - Q_{BH}^2 - \frac{Q_{BH}^1}{2} = 1 - \theta B'$$

$$\alpha - Q_{AB}^2 - \frac{Q_{AB}^1}{2} = 2 - \theta A' - \theta B'$$

$$\alpha - Q_{HK}^2 - \frac{Q_{HK}^1}{2} = 1 - \theta C'$$

$$\alpha - Q_{HC}^2 - \frac{Q_{HC}^1}{2} = 2 - \theta C' - \theta D'$$

$$\alpha - Q_{HD}^2 - \frac{Q_{HD}^1}{2} = 2 - \theta C' - \theta E'$$

$$\alpha - Q_{AK}^2 - \frac{Q_{AK}^1}{2} = 2 - \theta A' - \theta C'$$

$$\alpha - Q_{BK}^2 - \frac{Q_{BK}^1}{2} = 2 - \theta A' - \theta C'$$

$$\alpha - Q_{AC}^2 - \frac{Q_{AC}^1}{2} = 3 - \theta A' - \theta C' - \theta D'$$

$$\alpha - Q_{AD}^2 - \frac{Q_{AD}^1}{2} = 3 - \theta A' - \theta'' - \theta E'$$

$$\alpha - Q_{BC}^2 - \frac{Q_{BC}^1}{2} = 3 - \theta B' - \theta C' - \theta D'$$

$$\alpha - Q_{BD}^2 - \frac{Q_{BD}^1}{2} = 3 - \theta B' - \theta C' - \theta E'$$

$$\alpha - Q_{CD}^2 - \frac{Q_{CD}^1}{2} = 2 - \theta D' - \theta E'$$

$$\alpha - Q_{CK}^2 - \frac{Q_{CK}^1}{2} = 1 - \theta D'$$

$$\alpha - Q_{DK}^2 - \frac{Q_{DK}^1}{2} = 1 - \theta E'$$

$$\text{where } A = Q_{AH}^2 + Q_{AB}^2 + Q_{AK}^2 + Q_{AC}^2 + Q_{AD}^2$$

$$B = Q_{BH}^2 + Q_{AB}^2 + Q_{BK}^2 + Q_{BD}^2 + Q_{BC}^2$$

$$C = Q_{HK}^2 + Q_{AK}^2 + Q_{BK}^2 + Q_{AC}^2 + Q_{AD}^2 + Q_{BC}^2 + Q_{BD}^2 + Q_{HC}^2 + Q_{HD}^2$$

$$D = Q_{CK}^2 + Q_{HC}^2 + Q_{CD}^2 + Q_{BC}^2 + Q_{AC}^2$$

$$E = Q_{DK}^2 + Q_{HD}^2 + Q_{CD}^2 + Q_{BD}^2 + Q_{AD}^2$$

Given that the equilibrium arises when two airlines play Cournot game, the solutions are as following:

$$Q_{AH}^1 = Q_{BH}^1 = Q_{CK}^1 = Q_{DK}^1 = \frac{2(-1 + \alpha + 4\theta - 8\alpha\theta + 8\alpha\theta^2)}{3 - 34\theta + 48\theta^2}$$

$$Q_{AK}^1 = Q_{BK}^1 = Q_{CH}^1 = Q_{DH}^1 = \frac{2(-6 + 3\alpha + 4\theta - 6\alpha\theta + 8\alpha\theta^2)}{3(3 - 34\theta + 48\theta^2)}$$

$$Q_{AB}^1 = Q_{CD}^1 = \frac{-2(6 - 3\alpha - 24\theta + 14\alpha\theta)}{3(3 - 34\theta + 48\theta^2)}$$

$$Q_{HK}^1 = \frac{2(-3 + 3\alpha - 8\theta - 16\alpha\theta + 32\alpha\theta^2)}{3(3 - 34\theta + 48\theta^2)}$$

$$Q'_{AC} = Q'_{AD} = Q'_{BC} = Q'_{BD} = \frac{-2(9 - 3\alpha - 16\theta - 4\alpha\theta + 16\alpha\theta^2)}{3(3 - 34\theta + 48\theta^2)}$$

And for the second order condition, the  $\theta$  is constrained such that  $\theta < \frac{1}{72}(17 - \sqrt{145})$ .

The positive output and marginal revenue requires  $\frac{9 - 16\theta}{3 + 4\theta - 16\theta^2} < \alpha < \frac{-3 - 8\theta}{16\theta^2 - 18\theta}$ .

From the above results, the profit for airline1 is:

$$\pi_1 = \frac{A + 12\alpha B + 2\alpha^2 C}{9(3 - 34\theta + 48\theta^2)^2}$$

where

$$A = 1170 - 20970\theta + 61920\theta^2 - 51840\theta^3$$

$$B = -87 + 1563\theta - 4688\theta^2 + 4032\theta^3$$

$$C = 135 - 2517\theta + 9352\theta^2 - 12288\theta^3 + 4608\theta^4$$

And for airline 2, it has the same result for the symmetrical assumption.

### 3.4.2 Complete alliance model

Following the complete alliance, two partners link their networks by connecting their two hubs. The route between the partner's hubs can be an intercontinental route. Furthermore, by code sharing or block-space agreements, the partner airline can fly beyond the hub city. Thus on each city-pair, they jointly provide the service. For example, airline 1 can code-share with airline 2 on the routes KC and KD in airline 2's network. On the other way, airline 2 can code-share with airline 1 on the routes HA and HB in airline 1's network.

After the complete alliance, both airlines can fly not only between the two hub cities, but also between its own hub and the partner's non-hub cities. Furthermore, they make joint operation on each city-pair market.

Now on each city pair, suppose these two airlines are the only carriers. Then such alliances make the total profit maximize. This section is to examine the effects of such alliance on the output and total profits of the two airlines.



Consider the total profits of the two airlines, it has the form as follows:

$$\begin{aligned}\pi^{12} = & Q_{AH}^{12}D(Q_{AH}^{12}) + Q_{BH}^{12}D(Q_{BH}^{12}) + Q_{AB}^{12}D(Q_{AB}^{12}) + Q_{HK}^{12}D(Q_{HK}^{12}) + Q_{HC}^{12}D(Q_{HC}^{12}) + Q_{HD}^{12}D(Q_{HD}^{12}) + Q_{AK}^{12}D(Q_{AK}^{12}) \\ & + Q_{BK}^{12}D(Q_{BK}^{12}) + Q_{AC}^{12}D(Q_{AC}^{12}) + Q_{AD}^{12}D(Q_{AD}^{12}) + Q_{BC}^{12}D(Q_{BC}^{12}) + Q_{BD}^{12}D(Q_{BD}^{12}) + Q_{CD}^{12}D(Q_{CD}^{12}) + Q_{CK}^{12}D(Q_{CK}^{12}) \\ & + Q_{DK}^{12}D(Q_{DK}^{12}) - C(Q_{AH}^1 + Q_{AB}^1 + Q_{AK}^1 + Q_{AC}^1 + Q_{AD}^1) - C(Q_{BH}^1 + Q_{AB}^1 + Q_{BK}^1 + Q_{BC}^1 + Q_{BD}^1) \\ & - C(Q_{HK}^1 + Q_{AK}^1 + Q_{BK}^1 + Q_{AC}^1 + Q_{AD}^1 + Q_{BC}^1 + Q_{BD}^1 + Q_{HC}^1 + Q_{HD}^1) - C(Q_{CK}^1 + Q_{HC}^1 + Q_{CD}^1 + Q_{BC}^1 + Q_{AC}^1) \\ & - C(Q_{DK}^1 + Q_{HD}^1 + Q_{CD}^1 + Q_{AD}^1 + Q_{BD}^1)\end{aligned}$$

For the total profit maximization, the first order condition can be written as:

$$\alpha - Q_{AH}^{12} = 1 - \theta A$$

$$\alpha - Q_{BH}^{12} = 1 - \theta B$$

$$\alpha - Q_{AB}^{12} = 2 - \theta A - \theta B$$

$$\alpha - Q_{HK}^{12} = 1 - \theta C$$

$$\alpha - Q_{HC}^{12} = 2 - \theta C - \theta D$$

$$\alpha - Q_{HD}^{12} = 2 - \theta C - \theta E$$

$$\alpha - Q_{AK}^{12} = 2 - \theta A - \theta C$$

$$\alpha - Q_{BK}^{12} = 2 - \theta B - \theta C$$

$$\alpha - Q_{AC}^{12} = 3 - \theta A - \theta C - \theta D$$

$$\alpha - Q_{AD}^{12} = 3 - \theta A - \theta C - \theta E$$

$$\alpha - Q_{BC}^{12} = 3 - \theta B - \theta C - \theta D$$

$$\alpha - Q_{BD}^{12} = 3 - \theta B - \theta C - \theta E$$

$$\alpha - Q_{CD}^{12} = 2 - \theta D - \theta E$$

$$\alpha - Q_{CK}^{12} = 1 - \theta D$$

$$\alpha - Q_{DK}^{12} = 1 - \theta E$$

$$\text{where } A = Q_{AH}^{12} + Q_{AB}^{12} + Q_{AK}^{12} + Q_{AC}^{12} + Q_{AD}^{12}$$

$$B = Q_{BH}^{12} + Q_{AB}^{12} + Q_{BK}^{12} + Q_{BD}^{12} + Q_{BC}^{12}$$

$$C = Q_{HK}^{12} + Q_{AK}^{12} + Q_{BK}^{12} + Q_{AC}^{12} + Q_{AD}^{12} + Q_{BC}^{12} + Q_{BD}^{12} + Q_{HC}^{12} + Q_{HD}^{12}$$

$$D = Q_{CK}^{12} + Q_{HC}^{12} + Q_{CD}^{12} + Q_{BC}^{12} + Q_{AC}^{12}$$

$$E = Q_{DK}^{12} + Q_{HD}^{12} + Q_{CD}^{12} + Q_{BD}^{12} + Q_{AD}^{12}$$

Solving the above equations, the results are as follows:

$$Q_{AH}^{12} = Q_{BH}^{12} = Q_{CK}^{12} = Q_{DK}^{12} = \frac{-1 + \alpha + 6\theta - 12\alpha\theta + 18\alpha\theta^2}{1 - 17\theta + 36\theta^2}$$

$$Q_{AB}^{12} = Q_{CD}^{12} = \frac{-2 + \alpha + 12\theta - 7\alpha\theta}{1 - 17\theta + 36\theta^2}$$

$$Q_{HK}^{12} = \frac{-1 + \alpha - 4\theta - 8\alpha\theta + 24\alpha\theta^2}{1 - 17\theta + 36\theta^2}$$

$$Q_{AK}^{12} = Q_{BK}^{12} = Q_{CH}^{12} = Q_{DH}^{12} = \frac{-2 + \alpha + 2\theta - 3\alpha\theta + 6\alpha\theta^2}{1 - 17\theta + 36\theta^2}$$

$$Q_{AC}^{12} = Q_{AD}^{12} = Q_{BC}^{12} = Q_{BD}^{12} = \frac{-3 + \alpha + 8\theta + 2\alpha\theta - 12\alpha\theta^2}{1 - 17\theta + 36\theta^2}$$

The second order solution requires that  $\theta < \frac{1}{72}(17 - \sqrt{145})$ . The positive output and

marginal revenue require  $\frac{3 - 8\theta}{-12\theta^2 + 2\theta + 1} < \alpha < \frac{1 + 4\theta}{9\theta - 12\theta^2}$ .

The total profit for these two airlines is:

$$\pi^{1\&2} = \frac{65 - 180\theta + \alpha(-58 + 168\theta) + \alpha^2(-3 + 4\theta)(-5 + 18\theta)}{2 - 34\theta + 72\theta^2}$$

## 4. COMPARATIVE STATIC ANALYSIS

### 4.1 The effects of the bilateral agreement

Under the bilateral agreement, it can be shown that both airlines offer more outputs on markets AH, BH and AB for airline 1 and on markets CK, DK and CD for airline 2. The profits for both airlines increase after the agreement.

#### Proposition 1.a:

Airline 1 increases its service in markets AH, BH and AB after the bilateral agreement, which connects the two airlines' network by the inter-hubbing route of H and K.

*Proof:*

Using the results in the section 3.1 and 3.2, I compute the changes in airline 1's output due to the bilateral agreement:

$$\Delta Q_{AH} (= \Delta Q_{BH}) = -\frac{\theta[6 - 11\theta + \alpha(-3 + 3\theta + 4\theta^2)]}{(1 - 3\theta)(3 - 20\theta + 26\theta^2)}$$

$$\Delta Q_{AB} = -\frac{\theta[12 - 22\theta + \alpha(-6 + 6\theta + 8\theta^2)]}{(1 - 3\theta)(3 - 20\theta + 26\theta^2)}$$

The terms  $1 - 3\theta$ ,  $3 - 20\theta + 26\theta^2$  and  $\theta$  are all positive values for the feasible range of  $\theta$ . The bracketed term of the above two expressions are negative for the feasible range of  $\alpha$  and  $\theta$ .

The fact that the right side of the above two equations are positive implies that the airline 1 increase its outputs in the markets AH and AB due to the new route right HK. That is to say, the bilateral agreement not only makes the airline 1 offer services on new route HK, in markets AK and BK, but also increase its traffic on the original market AH, BH and AB. The similar situation also holds for airline 2.

**Proposition 1.b:**

The profit for both airlines increases after the bilateral agreements. After the bilateral agreement, for airline 1, it adds the route between its hub city H and airline 2's hub city K. For airline 1, the new route of HK not only expands its original service network- adding the service on city pair AK and BK, but also affects the marginal costs of providing service on the market AK, BK. For the economies of traffic density in airline network, the new route of HK reduces the costs of the network. Therefore, the profit for both airlines increases after the bilateral agreement.

*Proof:*

$$\Delta\pi_1 (= \Delta\pi_2) = \frac{A + \alpha B + \alpha^2 C}{2(1 - 3\theta)^2 (3 - 20\theta + 26\theta^2)^2}$$

where  $A = 184 - 2768\theta + 15998\theta^2 - 44406\theta^3 + 59208\theta^4 - 30420\theta^5$

$B = -224 + 3380\theta - 19619\theta^2 + 54876\theta^3 - 74492\theta^4 + 40584\theta^5 - 2028\theta^6$

$C = 76 - 1182\theta + 7187\theta^2 - 21722\theta^3 + 34084\theta^4 - 25828\theta^5 + 7044\theta^6$

It can be numerically shown that the change of the profit value is positive for the feasible range of  $\alpha$  and  $\theta$ . Thus both airlines benefit from the bilateral agreements and the profit increases after the agreement.

## 4.2 Effects of the “partial” alliance under the bilateral agreement

Next consider another situation where airline 1 and airline 2 make a “partial” alliance, in a sense that they compete in the market HK before, but now they jointly offer the flight between the two hub cities.

### Proposition 2.a:

Under the partial alliance, before alliance, two airlines compete on the market HK. After their alliance, the market HK becomes a monopoly one, the output on the inter-hub city pair market decreases.

*Proof:*

The change of output in market HK due to alliance is:

$$\Delta Q_{HK} = Q_{HK}^{1\&2} - Q_{HK}^1 - Q_{HK}^2 = \frac{1 - 2\theta(12 - 55\theta + 66\theta^2) + \alpha[-1 + 2\theta(10 - 47\theta + 68\theta^2 - 24\theta^3)]}{(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

The denominator is positive for the feasible range of  $\theta$ , while the nominator is negative for the feasible  $\alpha$  and  $\theta$ . Thus, the change of the output in market HK is negative, which implies that airline 1 and 2 decreases their combined output between the two hub cities H and K. Before alliance, the two airlines compete in the market HK. After alliance, the market HK becomes a monopoly one,  $Q_{HK}$  decreases as a result.

### Proposition 2.b:

After alliance, the service in each connecting market AK, BK for airline 1 and market CH, DH for airline 2 increases. Since the decrease of the output in HK market increases the marginal cost on HK segment, in order to compensate for the increase of marginal cost, airline 1 will increase the connecting traffic on markets AK and BK. And for airline 2, it will increase the output on markets CH and DH.

*Proof:*

Using the results known from section 3.2 and 3.3, I get the change of the two airlines' output due to the partial alliance as follows:

$$\Delta Q_{AK} (= \Delta Q_{BK} = \Delta Q_{CH} = \Delta Q_{DH}) = -\frac{\theta(1 - 3\theta)[13 - 24\theta + \alpha(-7 + 10\theta + 4\theta^2)]}{(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

The terms  $1 - 3\theta$ ,  $1 - 9\theta + 16\theta^2$ ,  $3 - 20\theta + 26\theta^2$ ,  $\theta$  are all positive for the feasible range of  $\theta$ . The bracket term of the right side of the equation is negative for the feasible range of  $\alpha$  and  $\theta$ . Therefore, the change of the traffic in market AK, BK, CH and DH is positive.

**Proposition 2.c:**

After the partial alliance, both airlines increase the output in their spoke routes. For airline 1, it increases the service in the markets AH and BH. For airline 2, it increases the output in the markets CK and DK.

*Proof:*

Using the solution in segments 3.2 and 3.3, I compute the changes of output in market AH, BH, CK and DK:

$$\Delta Q_{AH}^1 (= \Delta Q_{BH}^1 = \Delta Q_{CK}^1 = \Delta Q_{DK}^1) = -\frac{\theta^2[13 - 24\theta + \alpha(-7 + 10\theta + 4\theta^2)]}{(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

It has been shown that the bracket term in right side of the equation is negative for the feasible range of  $\alpha$  and  $\theta$ . Thus output change in market AH, BH for airline 1 and market CK, DK for airline 2 is positive. After alliance, both airlines increase the traffic on their spoke routes. Since the decrease in  $Q_{HK}$  increases the marginal cost on the segment HK, AK and BK, in order to compensate for that increase of the marginal cost, airline 1 therefore increases the output on markets AH and BH. As for airline 2, it increases its output between its hub K and the two spoke cities C, D respectively.

From the equations a, b, c, d, suppose the output on the market AK, BK for airline 1 and market CH, DH for airline 2 be constant, then the decrease of the traffic on market HK increases the marginal cost on the market AK, BK, CH, and DH. In order to set the marginal revenue equal to marginal cost,  $Q_{AK}, Q_{BK}, Q_{CH}, Q_{DH}$  should increase. Thus both airlines increase their local services after such alliance.

**Proposition 2.d:**

In the connecting market AB and CD, both airlines increase the connecting service via their hub H and K after the alliance. In section 3.3, from the equations of first order

condition about market AB, I can get that  $Q_{AB}^1 = \frac{\alpha + \theta(Q_{AH}^1 + Q_{AK}^1 + Q_{BH}^1 + Q_{BK}^1) - 2}{1 - 2\theta}$ , from

the proposition 2.b and 2.c,  $Q_{AH}^1, Q_{AK}^1, Q_{BH}^1, Q_{BK}^1$  all increase after the alliance, in order to set the equation hold in the new situation,  $Q_{AB}^1$  should increase as a result.

*Proof:*

It can be show that the change of output in market AB as:

$$\Delta Q_{AB}^1 (= \Delta Q_{CD}^2) = -\frac{2\theta^2[13 - 24\theta + \alpha(-7 + 10\theta + 4\theta^2)]}{(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

in which the nominator is negative and denomination is positive for the feasible range of  $\alpha$  and  $\theta$ , thus the change on market AB for airline 1 and on market CD for airline 2 is positive.

### Proposition 2.e:

As for the profits, it can be shown that the total profits for the two airlines increase after they make the partial alliance.

*Proof:*

$$\Delta \pi^{1\&2} = \pi^{1\&2} - \pi^1 - \pi^2 = \frac{A - 2\alpha B + \alpha^2 C}{2(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

where  $A = 1 + 352\theta - 3736\theta^2 + 13336\theta^3 - 19972\theta^4 + 10816\theta^5$

$B = 1 + 188\theta - 1992\theta^2 + 6960\theta^3 - 10132\theta^4 + 5312\theta^5$

$C = 1 + 96\theta - 1024\theta^2 + 3464\theta^3 - 4756\theta^4 + 2176\theta^5 + 192\theta^6$

It can be numerically shown that the right side of the above equation is positive for the feasible range of  $\alpha$  and  $\theta$ .

### 4.3. Effects of the “complete” alliance under the bilateral agreement (open sky agreement)

#### Proposition 3:

By “complete” alliance under the bilateral open sky agreement, the outputs in the following connecting markets AK, AC, AD, BK, BC, BD, CH and DH increase. For other markets AH, BH, CK, DK, AB, and CD, total output in each market decreases. As for the traffic between two hub cities H and K, the output decreases as well. The total profits for

airline 1 and 2 are lower in the situation where there is “complete” alliance between two airlines compared with that of no alliance.

*Proof:*

Using the results in section 3.4.1 and 3.4.2, the change of output in each market after the “complete” alliance is as follows:

$$\Delta Q_{AH} (= \Delta Q_{BH} = \Delta Q_{CK} = \Delta Q_{DK}) = \frac{1 - 32\theta + 164\theta^2 - 288\theta^3 + \alpha(-1 + 30\theta - 210\theta^2 + 508\theta^3 - 288\theta^4)}{(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

$$\Delta Q_{HK} = Q_{HK}^{1\&2} - Q_{HK}^1 - Q_{HK}^2 = \frac{3 - 106\theta + 152\theta^2 + 576\theta^3 + \alpha(-3 + 94\theta - 472\theta^2 + 880\theta^3 - 1152\theta^4)}{3(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

$$\Delta Q_{AB} (= \Delta Q_{CD}) = Q_{AB}^{1\&2} - Q_{AB}^1 - Q_{AB}^2 = \frac{6 - 192\theta + 984\theta^2 - 1728\theta^3 + \alpha(-3 + 95\theta - 526\theta^2 + 1008\theta^3)}{3(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

It is numerically shown that the nominator in the above three equations is negative for the feasible range of  $\alpha$  and  $\theta$ . The denominator is positive for the feasible  $\theta$ . Therefore the change of output in markets AH, HK and AB is negative, i.e., the output in these markets decreases as result of the “complete” alliance.

And it can be shown that:

$$\Delta Q_{AK} (= \Delta Q_{BK} = \Delta Q_{CH} = \Delta Q_{DH}) = \frac{6 - 202\theta + 644\theta^2 - 288\theta^3 + \alpha(-3 + 99\theta - 368\theta^2 + 364\theta^3 - 288\theta^4)}{3(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

$$\Delta Q_{AC} (= \Delta Q_{BC} = \Delta Q_{AD} = \Delta Q_{BD}) = \frac{9 - 298\theta + 1136\theta^2 - 1152\theta^3 + \alpha(-3 + 104\theta - 264\theta^2 - 152\theta^3 + 576\theta^4)}{3(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

The nominator of the above two equation is positive for the feasible range of  $\alpha$  and  $\theta$  implying that the outputs in these connecting markets increase after the “complete” alliance.

As for the profits, from section 3.4.1 and 3.4.2, the change of the total profits for these two airlines is:

$$\Delta \pi^{1\&2} = \frac{A - 2\alpha B + \alpha^2 C}{6(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)^2}$$

where

$$A = 195 + 9840\theta - 222300\theta^2 + 1062960\theta^3 - 1935360\theta^4 + 1244160\theta^5$$

$$B = 87 + 4320\theta - 98092\theta^2 + 472112\theta^3 - 875520\theta^4 + 580608\theta^5$$

$$C = -1755 + 65814\theta - 799804\theta^2 + 3678632\theta^3 - 7662624\theta^4 + 7114752\theta^5 - 2156544\theta^6$$

It can be shown numerically that the nominator is negative for the feasible range of  $\alpha$  and  $\theta$ , thus the total profits decrease as the result of “complete” alliance.

## 5. Effects on the price and economic welfare

### 5.1. Effects of the bilateral agreements

#### Proposition 5.1.a:

From the proposition 1.a, airline 1 produces more output in markets AH, BH and AB. For airline 2, it increases its traffic in markets CK, DK and CD due to the bilateral agreement. Therefore, the total outputs in these markets increase implying the reduction of the airfare in these markets. Furthermore, the new services are available on the inter-hub city pair HK and new flights from city A, B to K and from C, D to H. All above changes increase the consumer surplus in these markets, i.e., consumers are better off for the bilateral agreements.

*Proof:*

From the solution in section 4.1 and the assumption of the demand form, I get the changes of airfare in markets AH and AB as follows:

$$\Delta P_{AH} (= \Delta P_{BH} = \Delta P_{CK} = \Delta P_{DK}) = \frac{\theta[6 - 11\theta + \alpha(-3 + 3\theta + 4\theta^2)]}{2(1 - 3\theta)(3 - 20\theta + 26\theta^2)}$$

$$\Delta P_{AB} (= \Delta P_{CD}) = \frac{\theta[12 - 22\theta + \alpha(-6 + 6\theta + 8\theta^2)]}{2(1 - 3\theta)(3 - 20\theta + 26\theta^2)}$$

which are both negative for the feasible range of  $\alpha$  and  $\theta$ .

Combining the positive change of output in the markets, the consumer surplus increases and the increase of total consumer surplus in market AH can be computed by:

$$\Delta CS_{AH} = \frac{1}{2}(Q'_{AH} + Q_{AH}) * (-\Delta P_{AH})$$

where  $Q'_{AH}$  is the total output in market AH after the bilateral agreement.

Therefore,

$$\Delta C_{AH} = \frac{\theta(6 - 3\alpha - 11\theta + 3\alpha\theta + 4\alpha\theta^2)(6 - 6\alpha - 34\theta + 43\alpha\theta + 41\theta^2 - 89\alpha\theta^2 + 56\alpha\theta^3)}{4(1 - 3\theta)^2(3 - 20\theta + 26\theta^2)^2}$$

$$\Delta C_{AB} = \frac{\theta(6 - 3\alpha - 11\theta + 3\alpha\theta + 4\alpha\theta^2)(6 - 3\alpha - 34\theta + 14\alpha\theta + 41\theta^2 - 3\alpha\theta^2 - 22\alpha\theta^3)}{(1 - 3\theta)^2(3 - 20\theta + 26\theta^2)^2}$$



As for the consumer surplus in HK, AK and BK markets, it has the form as follows:

$$\Delta CS = \frac{1}{2}Q(\alpha - P)$$

Therefore,

$$\Delta CS_{AK} = \frac{(6 - 3\alpha - 11\theta + 3\alpha\theta + 4\alpha\theta^2)^2}{4(3 - 20\theta + 26\theta^2)^2}$$

$$\Delta CS_{HK} = \frac{4(1 - 2\theta)^2(1 - \alpha + 2\alpha\theta)^2}{(3 - 20\theta + 26\theta^2)^2}$$

Since the same results are for that in markets BH, CK, DK, CD, CH and DH, the total change of consumer surplus is as follows:

$$\Delta CS = \frac{A + 4\alpha B + C}{(1 - 3\theta)^2(3 - 20\theta + 26\theta^2)^2}$$

$$\text{where } A = 40 - 280\theta + 575\theta^2 - 294\theta^3 - 120\theta^4$$

$$B = -11 + 72\theta - 123\theta^2 + 14\theta^3 + 49\theta^4 + 36\theta^5$$

$$C = 13 - 92\theta + 249\theta^2 - 590\theta^3 + 1396\theta^4 - 1760\theta^5 + 768\theta^6$$

**Proposition 5.1.b:**

The aggregate social welfare increases after the bilateral agreement. Therefore, the bilateral agreement is socially desirable. By social welfare, I refer to the summation of the change in consumer surplus and change in profits of these two firms.

Using the proposition 5.1.a and 1.b, the change in aggregate social welfare can be written

$$\text{as: } \Delta W = \frac{A + \alpha B + \alpha^2 C}{(1 - 3\theta)^2(3 - 20\theta + 26\theta^2)^2}$$

where

$$A = 224 - 3048\theta + 16573\theta^2 - 44700\theta^3 + 59088\theta^4 - 30420\theta^5$$

$$B = -2060 + 69684\theta - 1069151\theta^2 + 9716450\theta^3 - 57952999\theta^4 + 238129788\theta^5 - 688136344\theta^6$$

$$+ 1399748056\theta^7 - 1967701352\theta^8 + 1828076304\theta^9 - 1021858032\theta^{10} + 274120704\theta^{11} - 12338352\theta^{12}$$

$$C = 697 - 23954\theta + 373732\theta^2 - 3465256\theta^3 + 21195451\theta^4 - 89962910\theta^5 + 271314592\theta^6 -$$

$$584774876\theta^7 + 891905616\theta^8 - 935729416\theta^9 + 637839984\theta^{10} - 251639856\theta^{11} + 42855696\theta^{12}$$

Effects of bilateral agreement on the consumer surplus, profits and social welfare:

$\theta$	$\underline{\alpha}$	$\bar{\alpha}$	$\alpha_1$	$\alpha_2$	$\underline{\Delta CS}$	$\overline{\Delta CS}$	$\underline{\Delta \pi}$	$\overline{\Delta \pi}$	$\underline{\Delta W}$	$\overline{\Delta W}$
0.02	1.96078	16.7051	2.83149	2.81388	0.420936	420.759	-87.1337	12652.6	-86.7128	13073.3
0.04	1.92308	8.37321	2.77422	2.74442	0.3976	110.541	-56.1104	1774.44	-55.7128	1884.9
0.05	1.90476	6.70732	2.72119	2.68262	0.385848	72.5842	-42.4888	826.884	-42.103	899.46
0.06	1.88676	5.59701	2.63965	2.59079	0.373923	51.7446	-30.0177	410.693	-29.6438	462.43
0.08	1.85185	4.20984	2.28067	2.22191	0.349359	30.7275	-8.09011	116.587	-7.74075	147.31
0.1	1.81818	3.37838	—	—	0.322747	20.8107	10.735	47.1645	11.0577	67.975
0.12	1.78571	2.82486	—	—	0.292287	15.3287	27.9749	38.0851	28.2672	53.413
0.14	1.75439	2.43026	—	—	0.254525	11.969	46.1394	48.5738	46.391	60.612
0.16	1.72414	2.13509	—	—	0.20238	9.75089	70.759	71.1953	70.9614	80.946
0.18	1.69492	1.90632	—	—	0.13056	8.19314	121.213	121.252	121.344	129.44
0.20	1.66667	1.72414	—	—	3.47126	7.02374	274.931	274.931	278.402	281.95

Table 1. Effects of bilateral agreement on consumer surplus, profits and social welfare

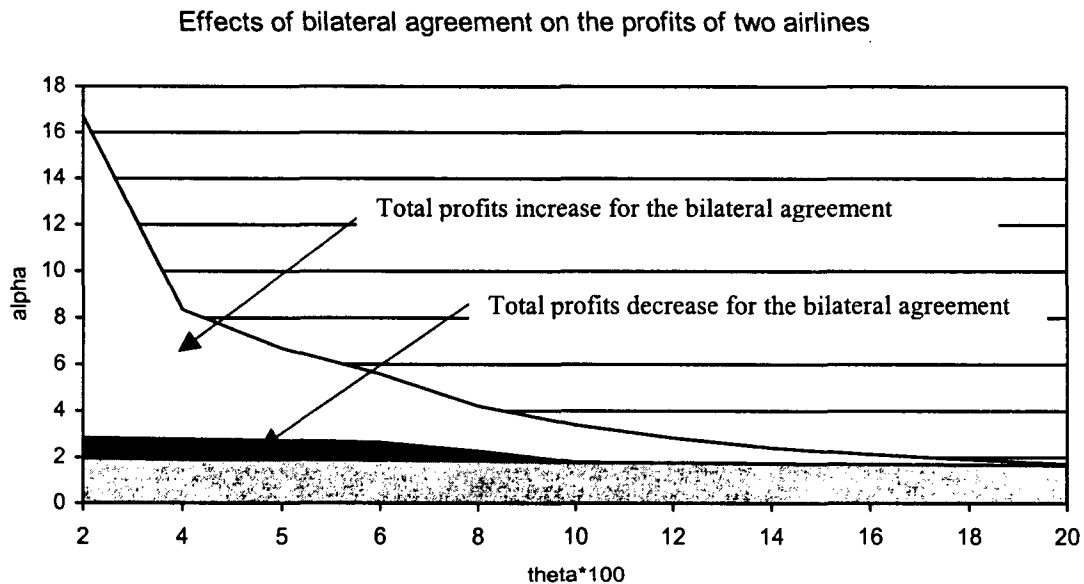
Table 1 shows the effects of bilateral agreement on the consumer surplus, profits and social welfare. Columns  $\underline{\alpha}$  and  $\bar{\alpha}$  indicate the lower and upper bounds of the demand intercept  $\alpha$ , which satisfy the requirement that both the output and marginal revenue are positive before and after the bilateral agreement.

Columns  $\underline{\Delta CS}$  and  $\overline{\Delta CS}$  represent the lower and upper bounds of the change of the consumer surplus due to the bilateral agreement given the feasible range of  $\alpha$  and  $\theta$ . As argued in proposition 4.1.a, these two columns show that the consumer surplus increases after the bilateral agreement. Furthermore, given a value of  $\theta$ , the increase of the consumer surplus gets larger as the market size increases.

Columns  $\underline{\Delta \pi}$  and  $\overline{\Delta \pi}$  show the different change given the lower and upper bound of  $\alpha$ , at different feasible values of  $\theta$ . It is shown that when  $\theta$  is less than 0.1, some range of  $\alpha$  gives the negative change of the total profits for the two airlines. For example, at  $\theta = 0.05$ , the total profits decrease after the bilateral agreement for  $1.90476 < \alpha < 2.72119$  and the profits increase for  $2.72119 < \alpha < 6.70732$ . The result shows that the extent to which the two airlines gain from the bilateral agreement gets greater as the market size increases. While for the higher value of  $\theta$ , for instance, when it is larger than 0.1, the

change of profits is positive for any feasible value of  $\alpha$ . In fact, if the economies of traffic density are high enough, the cost reduction from the increasing traffic density is high. Therefore, both airlines gain higher profits after the bilateral agreement.

As for the change of the social welfare, it has the similar trend as that for the total profits. Columns  $\underline{\Delta W}$  and  $\overline{\Delta W}$  show the change of welfare for lower and upper bound of  $\alpha$ , at different value of  $\theta$ . When  $\theta$  is low and at some lower value of  $\alpha$ , the gain to the consumers from the bilateral agreement is not high enough to compensate for the loss to the two airlines. Therefore, the social welfare decreases for the bilateral agreement. At higher value of  $\theta$ , the two airlines also gain from the agreement, thus the change of social welfare is positive for any feasible value of  $\alpha$ .



F

figure 1 The effects of bilateral agreement on the profits of the two airlines

In table 1, column  $\alpha_1$  shows the critical value of  $\alpha$  at which the change of profits is zero for any given value of  $\theta$ . For example, at  $\theta = 0.06$ , the change is negative for  $1.88676 < \alpha < 2.63965$ ; and it is positive for  $2.63965 < \alpha < 5.59701$ . In figure 1, the lower, upper and critical values of  $\alpha$  are drawn at the different value of  $\theta$ . The graph shows that the profits for the two airlines increase after the bilateral agreement if the

market size is large enough, or if the economies of density is high enough, but it decreases when the return to density is low and the market size is small.

In table 1, column  $\alpha_2$  shows the critical value of  $\alpha$  at which the change of social welfare equals zero at the given value of  $\theta$ . For instance, at  $\theta = 0.06$ , the change of welfare is positive for  $2.59079 < \alpha < 5.59701$ : and it is negative for  $1.88675 < \alpha < 2.59079$ . The graph in figure 2 draws the lower, upper and critical value of  $\alpha$  at different value of  $\theta$ . It shows that the social welfare increases after the bilateral agreement when the market size is sufficiently large or when the return to traffic density is high enough. At the given value of  $\theta$ , the change of the economic welfare is positive if the market size is sufficiently large, which implies that the benefits to the consumers outweigh the cost increase to the two airlines. As a result, the social welfare increases. Or, if the return to traffic density is sufficiently high, then the marginal costs decrease faster than those for weaker economies of density. The two airlines get higher profits after the bilateral agreement. Therefore, the social welfare increases. When the market size is relatively small and the degree of the economies of traffic density is lower, the gains to the consumers are not sufficiently large to compensate for the loss to the two airlines. As a consequence, the social welfare decreases after the bilateral agreement.

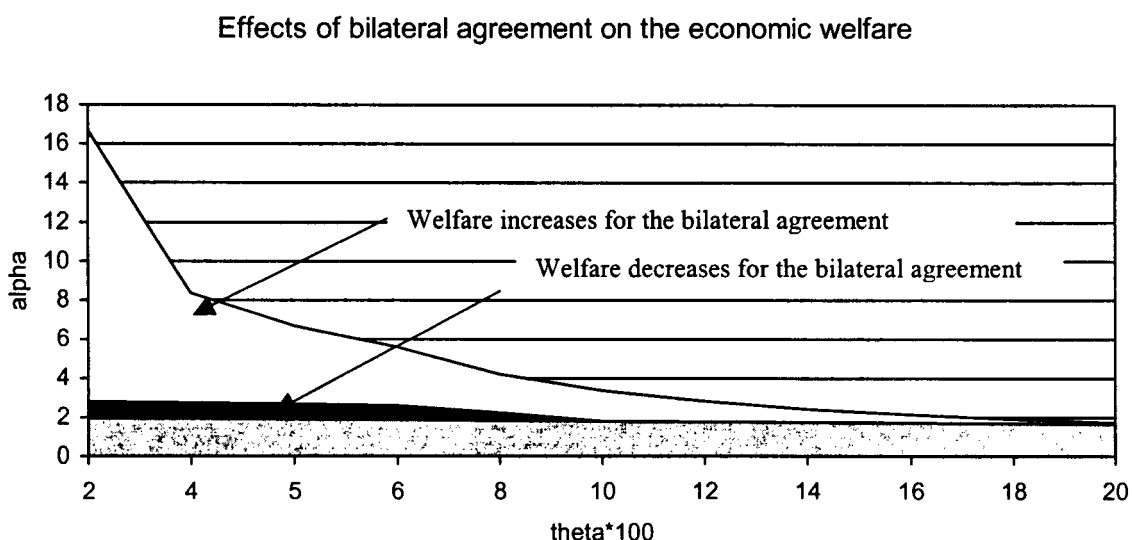


Figure 2: The effect of the bilateral agreement on the economic welfare

$$\Delta CS_{AB} =$$

$$\frac{\theta^2(13-7\alpha-24\theta+10\alpha\theta+4\alpha\theta^2)(6-3\alpha-64\theta+29\alpha\theta+199\theta^2-67\alpha\theta^2-184\theta^3-12\alpha\theta^3+100\alpha\theta^4)}{(1-9\theta+16\theta^2)^2(3-20\theta+26\theta^2)^2}$$

With the changes of consumer surplus in other markets, I get the change of overall

consumer surplus as:  $\Delta CS = \frac{A-2\alpha B+\alpha^2 C}{4(1-9\theta+16\theta^2)^2(3-20\theta+26\theta^2)^2}$ , in which

$$A = -7 + 856\theta - 10640\theta^2 + 50212\theta^3 - 110524\theta^4 + 114184\theta^5 - 44544\theta^6$$

$$B = -7 + 552\theta - 6572\theta^2 + 30606\theta^3 - 67868\theta^4 + 74852\theta^5 - 39600\theta^6 + 9120\theta^7$$

$$C =$$

$$-7 + 392\theta - 4584\theta^2 + 22664\theta^3 - 59804\theta^4 + 98816\theta^5 - 114304\theta^6 + 86656\theta^7 - 29696\theta^8$$

Combining the change of total profits in proposition 2.e, I get the change of the social welfare as:

$$\Delta W = \frac{A+\alpha B+\alpha^2 C}{4(1-9\theta+16\theta^2)^2(3-20\theta+26\theta^2)^2}$$

where

$$A = -1 + 2874\theta - 65636\theta^2 + 659120\theta^3 - 3771012\theta^4 + 13263488\theta^5 - 29091664\theta^6 + 38719056\theta^7 - 28600832\theta^8 + 8998912\theta^9$$

$$B = 2 - 3172\theta + 71376\theta^2 - 708020\theta^3 + 4004616\theta^4 - 13916728\theta^5 + 30110016\theta^6 - 39449184\theta^7 + 28631040\theta^8 - 8839168\theta^9$$

$$C = -1 + 874\theta - 19244\theta^2 + 187364\theta^3 - 1039684\theta^4 + 3533112\theta^5 - 7423824\theta^6 + 9325712\theta^7 - 6300160\theta^8 + 1597696\theta^9 + 159744\theta^{10}$$

Effects of partial alliance on consumer surplus, profits and social welfare

$\theta$	$\underline{\alpha}$	$\bar{\alpha}$	$\alpha_1$	$\alpha_2$	$\underline{\Delta CS}$	$\bar{\Delta CS}$	$\underline{\Delta \pi}$	$\bar{\Delta \pi}$	$\underline{\Delta W}$	$\bar{\Delta W}$
0.03	1.94175	7.0028	6.06397	2.0553	-0.173659	0.45836	0.141876	24.2832	-0.03178	24.8477
0.04	1.92308	5.34188	3.31729	2.0112	-0.166554	2.23997	0.132531	15.3447	-0.03402	17.6956
0.05	1.90476	4.34783	2.65466	1.97682	-0.159316	2.80984	0.122818	10.4773	-0.03650	13.4032
0.06	1.88679	3.68732	2.34943	1.94712	-0.151935	2.9918	0.112837	7.46026	-0.03910	10.5735
0.08	1.85185	2.86697	2.05372	1.89448	-0.136823	3.02287	0.092409	3.99334	-0.04443	7.14914
0.09	1.83486	2.59605	1.9701	1.87012	-0.12933	2.99616	0.082118	2.93191	-0.04724	6.0669
0.1	1.81818	2.38095	1.9078	1.84681	-0.122385	2.96708	0.071873	2.12704	-0.05056	5.2386
0.11	1.8018	2.20653	1.85999	1.82463	-0.117106	2.93908	0.061739	1.50421	-0.05546	4.5929
0.12	1.78571	2.06271	1.8227	1.8038	-0.116496	2.90719	0.051776	1.01525	-0.06490	4.0755

## 5.2. Effects of partial alliance

Now consider the effects of the partial alliance on the market price and social welfare under the bilateral agreement.

### Proposition 5.2.1:

For the partial alliance, the output in the joint market HK decreases, which results in the increasing airfare. The airfare change in the market HK is as follows:

$$\Delta P_{HK} = -\frac{\Delta Q_{HK}}{2} = -\frac{1 - 2\theta(12 - 55\theta + 66\theta^2) + \alpha[-1 + 2\theta(10 - 47\theta + 68\theta^2 - 24\theta^3)]}{2(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

The consumer surplus in market HK decreases and the change is negative:

$$\Delta CS_{HK} = -[-1 + 24\theta - 110\theta^2 + 132\theta^3 + \alpha(1 - 20\theta + 94\theta^2 - 136\theta^3 + 48\theta^4)][-7 + 64\theta - 162\theta^2 + 128\theta^3 + \alpha(7 - 84\theta + 354\theta^2 - 664\theta^3 + 464\theta^4)]/[4(1 - 9\theta + 16\theta^2)^2(3 - 20\theta + 26\theta^2)^2]$$

As for the consumer surplus in other markets, the outputs increase due to the “partial” alliance and thus airfare falls. The change of market price is as follows:

$$\Delta P_{AK} = \frac{\theta(1 - 3\theta)[13 - 24\theta + \alpha(-7 + 10\theta + 4\theta^2)]}{2(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

$$\Delta P_{AH} = \frac{\theta^2[13 - 24\theta + \alpha(-7 + 10\theta + 4\theta^2)]}{2(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

$$\Delta P_{AB} = \frac{\theta^2[13 - 24\theta + \alpha(-7 + 10\theta + 4\theta^2)]}{(1 - 9\theta + 16\theta^2)(3 - 20\theta + 26\theta^2)}$$

Consequently, the consumer surplus increases in all these markets.

$$\Delta CS_{AK} = [\theta(1 - 3\theta)(13 - 7\alpha - 24\theta + 10\alpha\theta + 4\alpha\theta^2)(12 - 6\alpha - 117\theta + 53\alpha\theta + 327\theta^2 - 111\alpha\theta^2 - 280\theta^3 - 2\alpha\theta^3 + 116\alpha\theta^4)]/[4(1 - 9\theta + 16\theta^2)^2(3 - 20\theta + 26\theta^2)^2]$$

$$\Delta CS_{AH} = \frac{\theta^2(13 - 7\alpha - 24\theta + 10\alpha\theta + 4\alpha\theta^2)(6 - 6\alpha - 64\theta + 76\alpha\theta + 199\theta^2 - 321\alpha\theta^2 - 184\theta^3 + 542\alpha\theta^3 - 316\alpha\theta^4)}{4(1 - 9\theta + 16\theta^2)^2(3 - 20\theta + 26\theta^2)^2}$$

0.13	1.76991	1.9425	1.79339	1.78459	-0.130091	2.85042	0.042047	0.62759	-0.08836	3.63112
0.14	1.75439	1.84094	1.77016	1.76705	-0.20187	2.6876	0.032607	0.31871	-0.16985	3.15224
0.15	1.73913	1.75439	1.74938	1.74888	-1.14271	1.19731	0.023497	0.07256	-1.12033	1.39304

Table 2. Effects of partial alliance on consumer surplus, profits and social welfare

Table 2 shows the effects of partial alliance on the change of consumer surplus, overall profits and the social welfare. Columns  $\underline{\alpha}$  and  $\bar{\alpha}$  are the lower and upper bounds of the demand intercept, which guarantee the positive values of output and marginal revenue before and after the partial alliance.

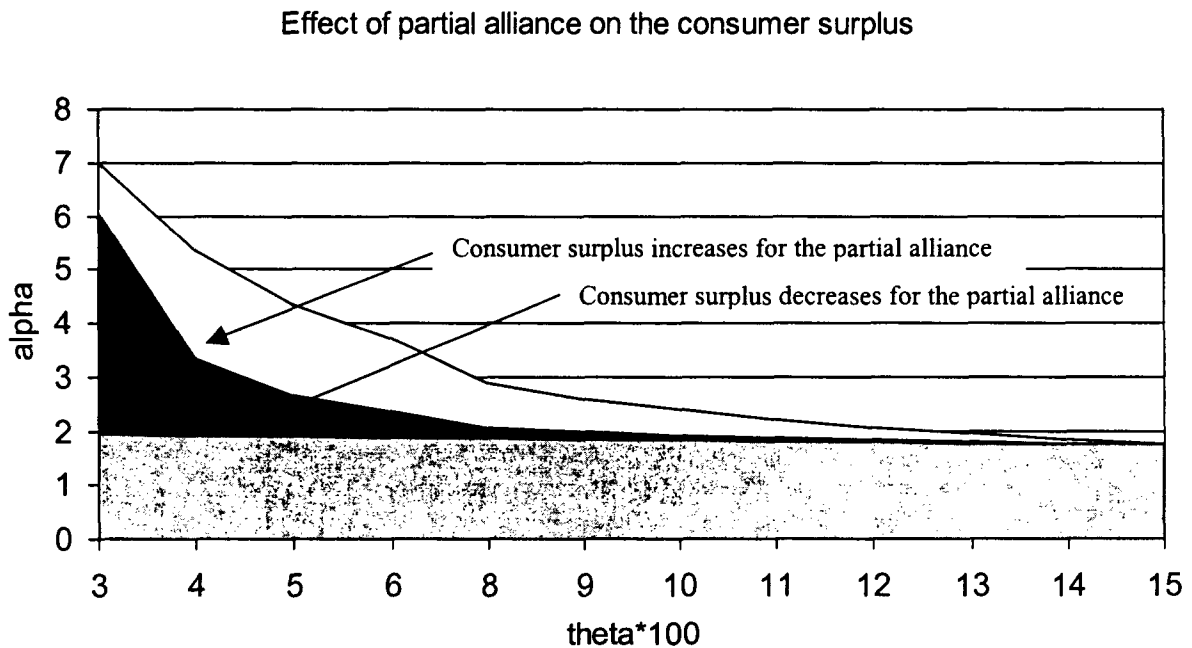


Figure 3. The effects of partial alliance on the consumer surplus

As for the change of consumer surplus after the partial alliance, it is shown from columns  $\underline{\Delta CS}$  and  $\bar{\Delta CS}$  that for any given value of  $\theta$  and the lower range of  $\alpha$  the consumer surplus decreases under the partial alliance. According to the proposition 5.2.1, passengers in market HK (inter- hub city pair) are worse off since the output in this market decreases and the corresponding airfare increases. Although, in other markets, passengers are better off for the increased output and decreased airfare, for the lower value of  $\alpha$ , such gains are

not high enough to compensate for the loss to passengers on the market between the two hub cities. Therefore, the overall consumer surplus decreases for the partial alliance. Column  $\alpha_1$  provides the critical value of  $\alpha$  at which the change of the consumer surplus in all the markets equals zero for the given value of  $\theta$ . For example, at  $\theta=0.06$ , change in overall consumer surplus is negative for  $1.88679 < \alpha < 2.34943$ ; and it is positive for  $2.34943 < \alpha < 3.68732$ . The lower, upper and critical values of  $\alpha$  are drawn in the figure above.

Columns  $\underline{\Delta\pi}$  and  $\overline{\Delta\pi}$  in Table 2 indicate the change of the profits to the two airlines after the “partial” alliance given the lower and upper bound of  $\alpha$  for the feasible range of  $\theta$ . As mentioned in proposition 2.e, the columns show the overall profits increase for the “partial” alliance. Furthermore, the two columns indicate that at a given value of  $\theta$ , the increase of the overall profits gets larger as the market size increases.

Next consider the effect of partial alliance on the social welfare. In table 2, columns  $\underline{\Delta W}$  and  $\overline{\Delta W}$  are the corresponding changes of social welfare given the lower and upper bounds of  $\alpha$  for the feasible values of  $\theta$ . As compared to the economic welfare before the partial alliance, the welfare decreases when the market size is overly small. Such decreases results from the decrease of the consumer surplus. Although the profits for the two airlines increase due to the partial alliance, the increase is not high enough to compensate for the losses to passengers. As market size gets larger, passengers gain from the partial alliance and the two airlines gain more profits due to the alliance. Therefore, the increase of the economic welfare gets larger as the market size increases.

The graph in figure 4 shows the change of economic welfare at the lower, upper and critical value for the given feasible range of  $\theta$ . In general, the economic welfare increases as result of the partial alliance since most areas below the upper bound of  $\alpha$  yield the positive change of the welfare.



### Effect of the partial alliance on the economic welfare

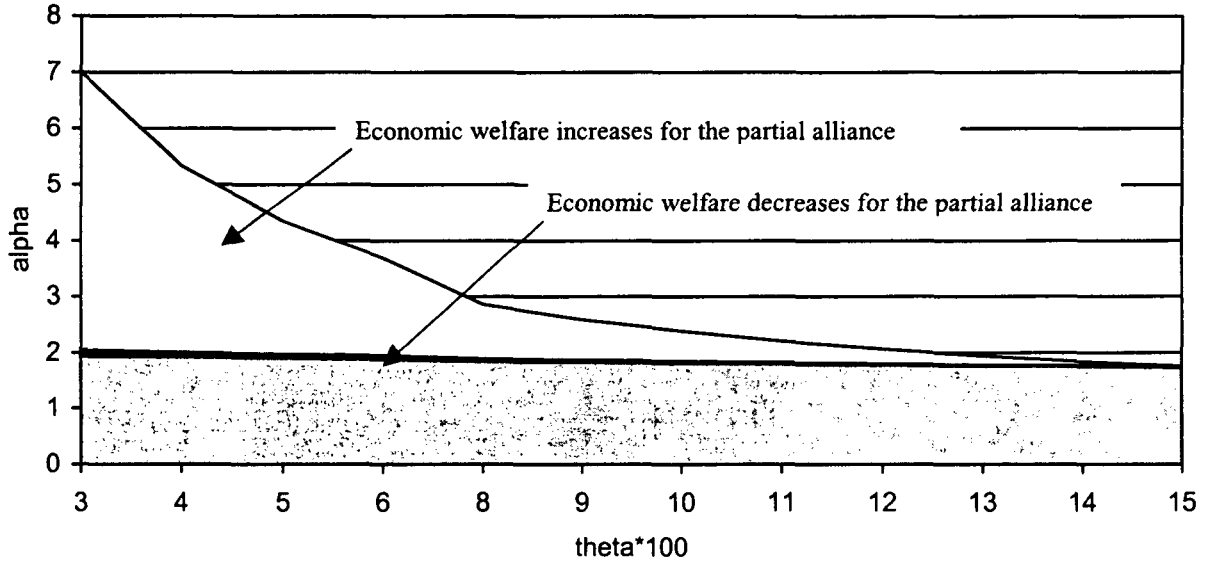


Figure 4. The effect of partial alliance on the economic welfare

### 5.3. Effect of complete alliance

#### Proposition 5.3.a:

The “complete” alliance results in the decrease of the total output and the increase of the airfare in markets AH, BH, CK, DK, HK, AB and CD. Therefore, the passengers in these markets are worse off due to the complete alliance.

The price change due to the complete alliance:

$$\Delta P_{AH} (= \Delta P_{BH} = \Delta P_{CK} = \Delta P_{DK}) = - \frac{1 - 32\theta + 164\theta^2 - 288\theta^3 + \alpha(-1 + 30\theta - 210\theta^2 + 508\theta^3 - 288\theta^4)}{2(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

$$\Delta P_{HK} = - \frac{3 - 106\theta + 152\theta^2 + 576\theta^3 + \alpha(-3 + 94\theta - 472\theta^2 + 880\theta^3 - 1152\theta^4)}{6(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

$$\Delta P_{AB} = - \frac{6 - 192\theta + 984\theta^2 - 1728\theta^3 + \alpha(-3 + 95\theta - 526\theta^2 + 1008\theta^3)}{6(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

Using the results in section 3.4.1 and 3.4.2, the consumer surplus in each market can be written as follows:

$$\Delta C_{AH} = -[(-1 + \alpha + 32\theta - 30\alpha\theta - 164\theta^2 + 210\alpha\theta^2 + 288\theta^3 - 508\alpha\theta^3 + 288\alpha\theta^4)(-7 + 7\alpha + 136\theta - 170\alpha\theta - 668\theta^2 + 1230\alpha\theta^2 + 864\theta^2 - 2884\alpha\theta^3 + 2016\alpha\theta^4)]/[4(1 - 17\theta + 36\theta^2)^2(3 - 34\theta + 48\theta^2)^2]$$

$$\Delta C_{HK} = -[(-3 + 3\alpha + 106\theta - 94\alpha\theta - 152\theta^2 + 472\alpha\theta^2 - 576\theta^3 - 880\alpha\theta^3 + 1152\alpha\theta^4)(-21 + 21\alpha + 2 - 442\alpha\theta + 376\theta^2 + 2824\alpha\theta^2 - 1728\theta^3 - 8080\alpha\theta^3 + 8064\alpha\theta^4)]/[36(1 - 17\theta + 36\theta^2)^2(3 - 34\theta + 48\theta^2)^2]$$

$$\Delta CS_{AB} = -[(6 - 3\alpha - 192\theta + 95\alpha\theta + 984\theta^2 - 526\alpha\theta^2 - 1728\theta^3 + 1008\alpha\theta^3)(42 - 21\alpha - 816\theta + 425\alpha\theta - 4008\theta^2 - 2242\alpha\theta^2 - 5148\theta^3 + 3024\alpha\theta^3)]/[36(1 - 17\theta + 36\theta^2)^2(3 - 34\theta + 48\theta^2)^2]$$

In markets AH, BH, CK, DK, HK, AB and CD, since the price increases and the outputs in these markets decrease after the “complete” alliance, the change of consumer surplus in these markets is negative.

**Proposition 5.3.b:**

In markets AK, BK, CH, DH, AC, BC, AD and BD, the complete alliance results in the increase of the outputs and the decrease of the corresponding airfare in each market. Consequently, passengers are better off due to the complete alliance.

Using the results in section 4.3, the change of airfare in these markets is negative and can be written as:

$$\Delta P_{AK} (= \Delta P_{BK} = \Delta P_{CH} = \Delta P_{DH}) = -\frac{6 - 202\theta + 644\theta^2 - 288\theta^3 + \alpha(-3 + 99\theta - 368\theta^2 + 364\theta^3 - 288\theta^4)}{6(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

$$\Delta P_{AC} (= \Delta P_{BC} = \Delta P_{AD} = \Delta P_{BD}) = -\frac{9 - 298\theta + 1136\theta^2 - 1152\theta^3 + \alpha(-3 + 104\theta - 264\theta^2 - 152\theta^3 + 576\theta^4)}{6(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

Next, the change of the consumer surplus in these markets can be calculated as follows:

$$\Delta CS_{AK} = -[(-6 + 3\alpha + 202\theta - 99\alpha\theta - 644\theta^2 + 368\alpha\theta^2 + 288\theta^3 - 364\alpha\theta^3 + 288\alpha\theta^4)(-42 + 21\alpha + 646\theta - 357\alpha\theta - 1628\theta^2 + 1376\alpha\theta^2 + 864\theta^3 - 2452\alpha\theta^3 + 2016\alpha\theta^4)]/[36(1 - 17\theta + 36\theta^2)^2(3 - 34\theta + 48\theta^2)^2]$$

$$\Delta CS_{AC} = \frac{2(3 - \alpha - 8\theta - 2\alpha\theta + 12\alpha\theta^2)(9 - 3\alpha - 16\theta - 4\alpha\theta + 16\alpha\theta^2)}{3(1 - 17\theta + 36\theta^2)(3 - 34\theta + 48\theta^2)}$$

In the markets above, the output increases and the airfare decreases due to the “complete” alliance. Obviously, consumer surplus in these markets increases and the change is positive. Therefore, the change of total consumer surplus in all the markets is as follows:

$$\Delta CS = \frac{A - 2\alpha B + \alpha^2 C}{36(1 - 17\theta + 36\theta^2)^2(3 - 34\theta + 48\theta^2)^2}$$

where

$$\begin{aligned}
A &= 5949 - 163620\theta + 1555924\theta^2 - 6731680\theta^3 + 12692800\theta^4 - 4838400\theta^5 - 7630848\theta^6 \\
B &= 1521 - 20460\theta - 237916\theta^2 + 4977920\theta^3 - 29340992\theta^4 + 78484480\theta^5 - 95182848\theta^6 + 39813120\theta^7 \\
C &= 171 + 14520\theta - 528702\theta^2 + 5879320\theta^3 - 29405064\theta^4 + 73398720\theta^5 - 87228032\theta^6 \\
&\quad + 38062080\theta^7 - 663552\theta^8
\end{aligned}$$

As for the change of the social welfare, it is calculated by the summation of the change of consumer surplus in all the markets and the change of the profits for the two airlines. It has the form as follows:

$$\Delta W = \frac{A + \alpha B + \alpha^2 C}{36(1 - 17\theta + 36\theta^2)^2(3 - 34\theta + 48\theta^2)^2}$$

where

$$\begin{aligned}
A &= 7119 - 124470\theta - 739436\theta^2 + 24446120\theta^3 - 155358080\theta^4 + 429632640\theta^5 \\
&\quad - 552572928\theta^6 + 268738560\theta^7
\end{aligned}$$

$$\begin{aligned}
B &= -4086 + 6828\theta + 2496632\theta^2 - 37498192\theta^3 + 207874816\theta^4 - 546494720\theta^5 \\
&\quad + 687034368\theta^6 - 330448896\theta^7
\end{aligned}$$

$$\begin{aligned}
C &= -10359 + 588414\theta - 12419634\theta^2 + 123746944\theta^3 - 623358936\theta^4 + 1692259392\theta^5 - 2480998784\theta^6 \\
&\quad + 1794816000\theta^7 - 466477056\theta^8
\end{aligned}$$

Effect of complete alliance on consumer surplus, profits and social welfare

$\theta$	$\underline{\alpha}$	$\bar{\alpha}$	$\alpha_1$	$\alpha_2^*$	$\underline{\Delta CS}$	$\bar{\Delta CS}$	$\underline{\Delta \pi}$	$\bar{\Delta \pi}$	$\underline{\Delta W}$	$\bar{\Delta W}$
0.005	2.95403	22.8188	9.99344	0.693643	-4.8110	251.992	-295.175	-17191.2	-299.986	-16939.2
0.01	2.90943	11.7117	7.4087	0.735241	-4.5634	61.7027	-291.753	-4602.97	296.316	-4541.27
0.015	2.86612	8.01209	5.9184	0.780379	-4.3088	27.2768	-288.153	-2189.52	-292.461	-2162.24
0.02	2.82405	6.16438	4.95163	0.829913	-4.0419	15.5285	-284.197	-1316.24	-288.239	-1300.71
0.025	2.78317	5.05747	4.27618	0.884959	-3.7548	10.2454	-279.637	-898.067	-283.392	-887.821
0.03	2.74343	4.32099	3.77985	0.947041	-3.4356	7.47035	-274.121	-662.269	-277.556	-654.779
0.035	2.70478	3.7962	3.40193	1.01814	-3.0645	5.86	-267.136	-513.549	-270.2	-507.689
0.04	2.66718	3.40376	3.10674	1.10128	-2.6071	4.85701	-257.926	-411.083	-260.533	-406.226
0.045	2.63058	3.09955	2.87209	1.20079	-1.9956	4.19275	-245.339	-334.513	-247.334	-330.321
0.05	2.59494	2.85714	2.68361	1.3234	-1.0785	3.72084	-227.569	-272.166	-228.648	-268.445
0.055	2.56022	2.65969	—	1.48006	0.561953	3.34664	-201.68	-216.068	-201.118	-212.721
0.058	2.53982	2.55797	—	1.59766	2.42621	3.13685	-180.287	-182.552	-177.861	-179.416

Table 3: Effects of complete alliance on consumer surplus, profits and social welfare

Table 3 shows the effects of complete alliance on the consumer surplus, profits and social welfare. Columns  $\underline{\alpha}$  and  $\bar{\alpha}$  indicate the lower and upper bound of the demand intercept respectively, which guarantee the output and marginal revenue are positive before and after the complete alliance.

Columns  $\Delta CS$  and  $\overline{\Delta CS}$  show the change of consumer surplus at the lower and upper bound of  $\alpha$  for the feasible range of  $\theta$ . It is shown that for any given value of  $\theta$ , when market size is small, consumer surplus decreases due to the complete alliance. The gains to passengers from the alliance increase as the market size gets larger.

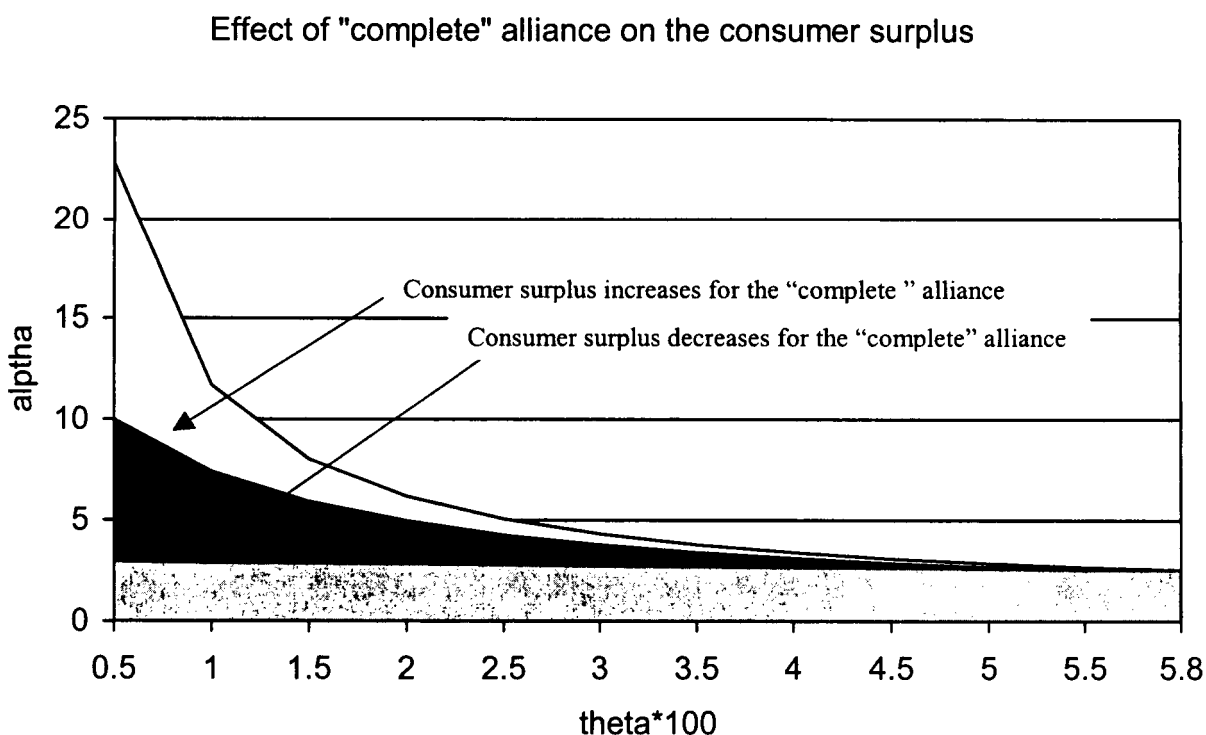


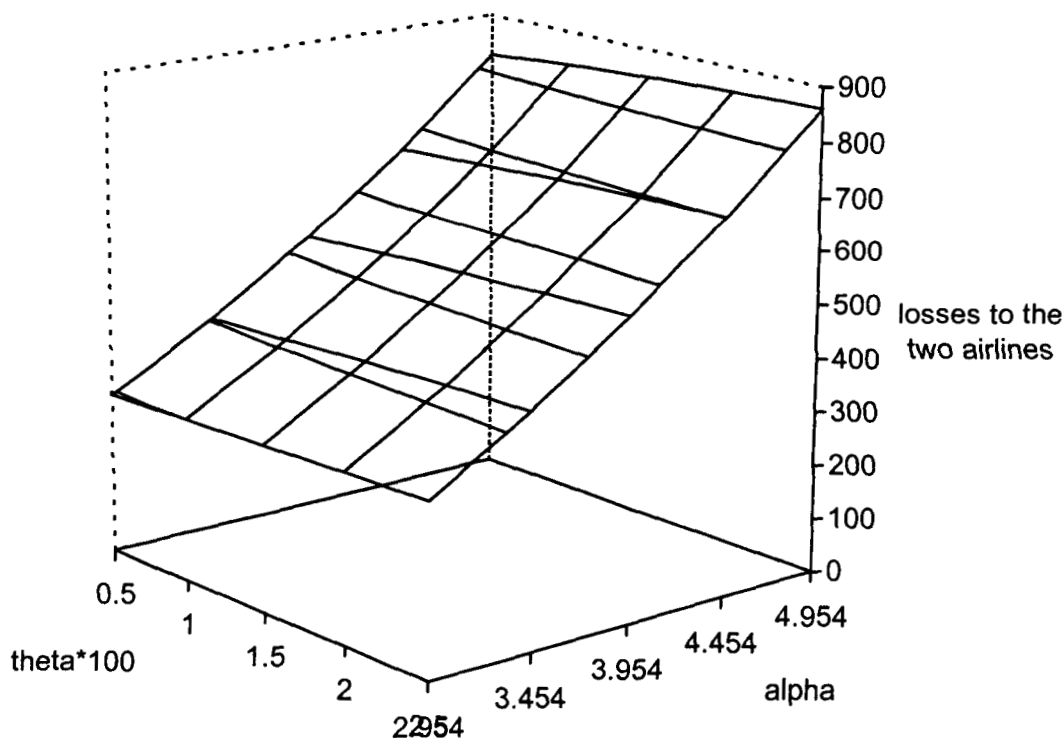
Figure 5: The effects of complete alliance on consumer surplus

As shown in Figure 5, where the lower, upper and critical values of  $\alpha$  are drawn in the graph, consumer surplus decreases when market size is relatively small for given value of  $\theta$ . For example, at  $\theta = 0.05$ , the change of consumer surplus is negative for  $2.59494 < \alpha < 2.68361$ ; and it is positive for  $2.68361 < \alpha < 2.85714$ . As mentioned in proposition 5.3.b, passengers are better off in the connecting markets AK, BK etc. for the complete alliance, but worse off in other local markets AH, for example. Therefore the

change of total consumer surplus is negative when market size is small. As market size gets larger, the gains to passengers in the connecting markets are higher than the losses to the local passengers, so the total consumer surplus increases. Furthermore, the graph shows that when the value of  $\theta$  is large, the change of consumer surplus is positive for the full range of feasible  $\alpha$ . It is reasonable since when the economies of traffic density is sufficiently high, marginal costs decrease faster from the increase of the traffic density as compared to that at lower value of  $\theta$  and for the alliance partner, they are willing to provide more connecting services. Therefore, the gains to connecting passengers are sufficiently high to compensate the losses to the local passengers. Therefore, the overall consumer surplus increases due to the complete alliance.

Next consider the effects of complete alliance on the profits of the two airlines. In table 3, columns  $\underline{\pi}$  and  $\bar{\pi}$  shows that the changes of profits for the two airlines are both negative for the lower and upper bound of  $\alpha$  at all the feasible value of  $\theta$ . Furthermore, the losses for the alliance partners increase as the market size gets larger. The detailed result is shown in Figure 6.

Effect of "complet" alliance on the profits of airlines



The above graph shows that the overall profits for the two airlines decrease after the complete alliance. Furthermore, the two partners lose more, as the market size gets larger. While for the given value of  $\alpha$ , the different values of  $\theta$  have little effects on the losses to the two partners. Such result seems a little unexpected, but it still deserves some consideration. The economies of traffic density have been empirically and theoretically shown to be evident in the airline industry, while for the economies of scope, the conclusion is not definite yet. In the case of complete alliance, the extent of the economies of scope is great enough since airline partners jointly provide services in the most extensive network. The decrease of the profits for the two partners implies that the negative effects with the expansive scope in airline network outweigh the positive effects with the increasing traffic density.

**Proposition 5.3.c:**

The overall profits for airlines decrease for the complete alliance and the losses to the alliance partners increase as market size gets larger. Therefore, the complete alliance makes the society worse off, even though passengers may benefit in certain condition.

## 6.CONCLUSION

The paper examines the effects of two types of airline alliance on the airline's output, profits and economic welfare on the basis of the two airlines' hub and spoke networks.

Firstly, the comparison before and after the simple form of the bilateral agreement is made to investigate the effect of combining the two airlines' separate hub and spoke networks. It is shown that by the agreement, the two airlines extend their service networks and increase the output in each market to exploit the economies of density. Passengers in both local and connecting markets are better off and the benefits are not only from the increased services, decreased airfare, but also from the more city pairs available, which are beyond the boundary of the individual airline network.

Secondly, under the background of the simple bilateral agreement, the partial alliance in the market between the two hub cities makes passengers worse off in that market, it increases the welfare of passengers in all other city-pair markets served by the two airlines.

The reason for this result is straightforward. Before alliance, the two airlines compete in the market connecting the two hub cities. After they make the partial alliance, the market becomes a monopoly one. Therefore, the output in the market connecting the two hub cities falls. Given the economies of density and cost complementarities, this traffic reduction raises the marginal cost on the other affected markets of the two alliance partners. In order to compensate for the increase of the marginal cost, both airlines increase the output in other markets. Consequently, passengers in these markets benefit from the increase of service and the lower airfare. In this case, partial alliance generates positive externalities outside the market where it occurs. The result also shows that as the extent of the increasing return to traffic density increases, the critical value of the market size gets lower above which the consumer surplus in all the markets increases after the partial alliance. Since the high return to density stimulates the two airlines to increase the output in other markets, the gain to passengers in these markets is high enough to outweigh the loss to the passengers in the inter-hub city-pair market. As for the alliance partners, it is shown that the profits for the two airlines increase after the partial alliance. The increase can be explained by the exploitation of the economies of density. Furthermore, the gains to the two partner airlines get larger as the market size increases.

Thirdly, for the complete airline alliance, which is under the background of the open sky bilateral agreement, only those passengers whose flights combine the two airline networks benefit from the increased services and decreased airfare. As for the two alliance partners, the total profits fall after the complete alliance and the losses to them increase as the market size gets larger. The economic welfare definitely decreases for the complete alliance. Such results come from a radical example, but it seems to support that some saturate extent of the alliance exists above which the negative effects with the alliance outweigh the positive ones. Therefore, for both airlines and passengers, they are worse off due to the alliance.

These findings have several important implications for the air transport policy and the airline strategy. First of all, considering the fact that more and more airlines have taken the hub and spoke network, the bilateral agreement between governments can make airlines on the two sides better exploit the economies of traffic density. For passengers, they also benefit from the agreement. Second, as for the partial alliance, only those passengers

whose origin and destination points are the two hub cities are worse off. For passengers in other markets, the partial alliance benefits them. The two partner airlines also get more profits after the partial alliance. In general, the partial alliance increases the economic welfare, except under the situation when the market size is extremely small.

Consequently, governments on both sides should be more supportive in allowing such partial alliance. Finally, the benefits with the strategic alliance to passengers and airline partners relate with the extent of the alliance. For the case of the complete alliance, most passengers and alliance partners are worse off due to the alliance. Therefore, for the alliance to be successful, the airlines must take into account the effects of economies of scope, economies of density and the market size.

In this paper, several assumptions are made for the convenience of analysis, for example, the symmetrical assumption of network structure and the assumption of the same market demand. Further research needs more flexible assumptions. Taking the shift of the demand after alliance into account is necessary to analyze the effects of alliance more exactly. Finally, for the limitation of the data available, the study is restricted in the theoretical investigation. When sufficient data become available, some empirical work can be done to testify the specific results.

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